

**TAB 10**

**FDA Reviewer's Literature Survey to Determine  
Correlation of Infection Rates to Microbiological  
Endpoints:**

- **Healthcare Personnel Handwashes – Colleen Rogers, Ph.D.**
- **Surgical Hand Scrubs – Michelle M. Jackson, Ph.D.**
- **Patient Preoperative Skin Preparations – Peter Kim, M.D.**



## HEALTHCARE ANTISEPTIC DRUG PRODUCTS REVIEW

---

Food and Drugs Administration  
Center For Drug Evaluation and Research  
Division of Over-the-Counter Drug Products (HFD-560)

---

<b>REVIEW DATE:</b>	March 11, 2004
<b>FDA DOCKET NO.:</b>	75N-183H
<b>PHARMACOLOGICAL CATEGORY:</b>	Healthcare Antiseptic Drug Products: Surgical Hand Scrub
<b>REVIEWER:</b>	Michelle M. Jackson, Ph.D.

---

### **Purpose:**

In the preparation for the meeting with the Nonprescription Drugs Advisory Committee (NDAC) meeting on March 23, 2005, reviewers of the Healthcare Antiseptic Working Group conducted a literature search to determine if there were any direct link between bacterial log reduction and decreased hospital infection rates pertaining to the use of surgical hand scrubs. Articles pertaining to surgical hand scrubs were first selected from the "Guideline for Hand Hygiene in Health-Care Settings: Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force." Articles published between 1974 and February 2004 using eight databases (PUBMED, IPA, EMBASE, CINAHL, DIALOGSELECT, BIOSIS, PASCAL, & SCISEARCH) were selected for review. The literature search terms for surgical hand scrub articles included the following: "surgical scrub," "antiseptic," "antimicrobial," "antibacterial," "efficacy," "clinical trials," "operating room," "handwashing," "hand scrubbing," "infection," "disinfection," "antiseptic," "log reductions," "povidone iodine," "alcohol," "ethanol," "chlorhexidine gluconate," "triclosan," and "chloroxylenol." The reviewers screened over 300 articles (Appendix I) in order to put together a meta-analysis. However, the reviewers were unable to perform a meta-analysis on the correlation of infection rates to microbiologic endpoints for surgical hand scrubs due to inadequate information and variability of the study designs. This review represents a literature summary on several references found that may have some association to clinical benefit in the reduction of microbial counts on the skin obtained with surgical hand scrubs.

### **Background:**

The purpose of surgical hand scrub is to remove transient bacteria, to reduce the resident flora, inhibit rapid rebound growth of bacteria, minimize regrowth of bacteria for the length of the procedure, or as long as possible, and to reduce the number of bacteria on hands and reduce

contamination of the operative site by recognized or unrecognized breaks in surgical gloves. Postoperative wound infections involving flora from the surgeon's hands where perforations and tears from the gloves do occur. However, most infections can be attributed to endogenous organisms from the patient, either a breach of sterile technique, inadequate preparation of the skin, or inadequate antibiotic prophylaxis.

In the FEDERAL REGISTER of June 17, 1994, FDA published an amendment to the tentative final monograph (TFM) for over-the-counter (OTC) healthcare antiseptic drug products (59 FR 31402) for professional use. The proposed rule defined performance expectation for surgical hand scrub as an antiseptic containing preparation that significantly reduces the number of microorganisms on intact skin; it is broad spectrum, fast acting, and persistent. The surgical hand scrub indicated use is significantly reduces the number of microorganisms on the skin prior to surgery. In order for an antiseptic ingredient to be generally recognized as effective for use as a surgical hand scrub, it must have existing data from well designed clinical studies demonstrating effectiveness. FDA has proposed specific criteria for final formulation of surgical hand scrubs that are based on the recommendations of the Panel and FDA experience in evaluating the effectiveness of this type of drug product approved through the new drug approval process. The 1994 TFM proposed the following criteria for surgical hand scrubs:

1994 TFM Current Reductions		
Day 1, Wash 1	Day 2*, Wash 2	Day 5*, Wash 11
1 log <sub>10</sub> in 1 min AND bacterial count does not exceed baseline within 6 hours on day 1	2 log <sub>10</sub> in 1 min	3 log <sub>10</sub> in 1 min

\* Sampling is taken on the second day and fifth day to demonstrate the substantive activity of antimicrobial products.

## **Literature Review**

**Boyce, JM, Potter-Bynoe, G, Opal, SM, Dziobek, L, and Medeiros AA. "A common-source outbreak of *Staphylococcus epidermidis* infections among patients undergoing cardiac surgery." J Infect Dis. 1990 (161):493-9.**

This article reported a common-source outbreak of infections related to cardiac surgery that was traced to colonization of a surgeon's hand by a strain of *Staphylococcus epidermidis*.

**DESIGN & METHODS:** This single strain of *S. epidermidis* caused an outbreak of postoperative wound infections and endocarditis during a 6-month period. Infections caused by the epidemic strain developed more frequently in valve surgery patients than in those undergoing coronary artery bypass graft surgery ( $P = .03$ ) and occurred only in patients operated on by surgeon A. None of 17 members of the cardiac surgery team carried the epidemic strain in their anterior nares, axillae, or inguinal folds. Hand cultures were performed on 8 surgical personnel, and only surgeon A carried the

epidemic strain on his hands. Isolates from cardiac surgery patients, bypass pump blood cultures, and the hands of the implicated surgeon all had identical antimicrobial susceptibility patterns, plasmid profiles, and EcoRI restriction endonuclease digest patterns.

**RESULTS:** The investigation revealed that surgeon A had been using a nonantimicrobial preparation for scrubbing his hands for several years because he had previously developed a dermatitis attributed to an antimicrobial scrub solution. Surgeon A recently adopted the practice of applying sterile mineral oil to his hands before donning gloves at the time of surgery. Surgeon A was not allowed to perform cardiac surgery until the epidemic strain was eradicated from his hands. He was required to use an antimicrobial scrub solution containing chlorhexidine daily for 2 weeks. Sampling was taken after scrubbing and after he had been gloved for 3-4 hours.

***Reviewer's comments:** What the study shows, despite its deficiencies is that there was an eradication of *S. epidermidis* from the surgical field 24 months after implementation of the infection control measures. The findings suggest that the common-source outbreak of infections among cardiac surgery patients was due to carriage of a strain *S. epidermidis* on the hands of a cardiac surgeon. The epidemic strain may come from a variety of other sources: endogenous flora of the patient, members of the cardiac team and technicians, surgical equipment, suction pump, operating room air, blood or other fluids, contaminated prosthetic valves, contaminated disinfectants, etc...The mechanism by which Surgeon A contaminated the operative field was not determined. Surgeon A was advised not to add mineral oil to his hands. Since the epidemic strain was isolated from blood cultures after the surgery, it was concluded that contamination may have resulted from glove tears during the surgery. However, this was not documented. Other factors that may have been responsible for the sudden increase in infections caused by the epidemic strain were also not determined. Further, details about the use of chlorhexidine gluconate as a surgical hand scrub were not provided. It is also not clear what if any infection control measures for other staff were instituted. This article basically shows that use of an antimicrobial scrub solution reduces the amount of colonizing *S. epidermidis* from the hands.*

**Bryce, EA, Spence, D, and Roberts, F. "An in-use evaluation of an alcohol-based pre-surgical hand disinfectant." *Infect Control Hosp Epidemiol* 2001 (22):635-639.**

The objective of this study was to determine whether alcohol hand disinfection is an effective alternative to traditional agents for the pre-surgical scrub.

**DESIGN & METHODS:** A prospective clinical trial of a 70% isopropanol pre-surgical hand disinfectant Manorapid (antiseptic product) involving the operating room suites at two hospital sites in British Columbia. The cases were selected to evaluate both short and longer procedures. The hand disinfectant was compared to agents in current use as surgical scrubs (4% chlorhexidine and 7.5% povidone-iodine). Surgical technique and glove use were not modified. Surgical personnel scrubbed (using traditional solutions and brushes) for 3 minutes after cleaning under the fingernails with a nail pick, according to operating room guidelines. The alcohol hand antiseptic was used as follows: hands were washed with a mild neutral soap for 1 minute prior to the first case of the day, hands

were dried, and approximately 5 mL of the alcohol product was dispensed into a cupped hand. Staff were instructed to dip their opposing fingernails into the solution, then transfer the Manorapid to the other hand and do the same to the other fingernails; the remaining product was used to rub all areas of the hands to the wrist. A second 5 mL of solution was dispensed and the liquid dispersed up both arms to the elbows and rubbed into the skin. A third 5 mL of product then was rubbed into the hands. Total time for the surgical hand rub was approximately 3 minutes. Pre- and postoperative fingertip impression and "glove-juice" cultures were used to determine microbial burden, and hands were evaluated for skin integrity.

**RESULTS:** There was no statistical difference between the microbial hand counts following use of the alcohol-based product or the current agents, for cases less than 2 hours' duration. Comparison of longer surgical cases revealed significantly better pre- and postoperative culture results with the alcohol hand rinse, but analysis of matched pairs showed no significant difference in microbial counts. The alcohol hand rinse was equivalent to the operative scrub in terms of skin integrity and user acceptability.

***Reviewer's comments:** The authors concluded that an alcohol hand rinse was equivalently effective in reducing microbial hand counts as the traditional pre-surgical scrub, both immediately after hand disinfection and at the end of the surgical procedure. There were several deficiencies in the study. Demographics and disposition of the subjects were not provided. Many variables (factors) in the studies, such as glove type, glove liners, other skin agent use, and use of antibiotics and oral contraceptives (causes an adverse effect on the microbial flora of the skin) were uncontrolled. There was no washout between treatment periods. The washout period is important because subjects crossed over from more persistent antimicrobials to the alcohol. The participants were given no specific instructions regarding their use of antimicrobial-containing products such as deodorants, shampoos, lotions, or soaps, nor were they provided with kits containing non-antimicrobial personal-care products for use during the evaluation. Overall, the information gathered from this study just showed that alcohol-based product was a comparable agent to those that were currently in use and effective if used according to recommendations. There was no valuable information regarding the correlation of infection rates to the reduction of bacteria. There was no clinical relevance depicted in the study.*

**Cremieux, A, Reverdy, ME, Pons, JL, Savage, C, Chevalier, J, Fleurette, J, Mosse, M. Standardized method for evaluation of hand disinfection by surgical scrub formulations. Appl Environ Microbiol 1989;55:2944-2948.**

The objective of the study was to assess the validity of a protocol on the basis of statistical analysis and to compare the two antiseptic scrub formulations (povidone iodine (PVI) and chlorhexidine (CHX)) with each other and with the nonmedicated soap (NMS). A standardized protocol for the evaluation of hand disinfection by surgical scrub formulations was applied to volunteers in a multicenter trial.

**METHODS:** Adult volunteers were gathered for each of the three studies (PVI, CHX, and NMS) in seven groups corresponding to distinct centers. All centers were involved

in the PVI study (49 subjects, seven groups of 10, 6, 8, 6, 10, 6, and 3 subjects), while one center was missing for the NMS study (41 subjects, six groups of 10, 6, 7, 6, 6, and 6 subjects) and two centers were missing for the CHX study (35 subjects, five groups of 10, 6, 8, 8, and 3 subjects). All subjects were instructed to avoid the use of antiseptics, detergents, and gloves during the experiment. Subjects were not prescreened for an adequate baseline count. The scrubbing procedure involved three daily hand washings occurring on day 2-4; surviving bacteria were counted daily after being collected in a suitable neutralizing solution. Immediate efficacy (IE), cumulative efficacy (CE), and remanent effect (RE) were calculated by reference to the control hand. Hand flora was recovered in a sterile plastic bag containing 400 ml of a neutralizing solution which has previously been demonstrated as convenient for the two scrub formulations and the soap. Five minutes after the end of the scrubbing procedure, the appropriate hand (left hand for control counts and right hand for test formulation) was plunged into the bag and agitated for 5 minutes. The solution was then transferred into a sterile bottle. Samples were placed in 15 ml tryptic soy agar. Colonies were counted after 48 hours of aerobic incubation at 37°C. All counts were conducted in duplicate.

**RESULTS:** Statistical analyses of IE, CE and RE showed significant differences among the three scrub formulations. IEs of PVI and CHX were equivalent and different from IE of NMS; CE and RE of CHX were higher than those of PVI and NMS. Statistical analysis was limited to IE on day 1, CE on day 5 and RE on day 8.

TABLE 2. Results of IE, CE, and RE with three scrub formulations for one group (10 subjects)

Day	Scrub formulation	Control (C1 <sup>a</sup> or Cd <sup>a</sup> )	Test (T1 <sup>a</sup> or Td <sup>a</sup> )	IE (C1 - T1; Cd - Td)	CE (C1 - Td)	RE (C1 - Cd)
1	PVI	6.48 ± 0.98 <sup>a</sup>	5.78 ± 1.07	0.70 ± 0.79		
	CHX	6.51 ± 0.58	5.75 ± 0.69	0.76 ± 0.53		
	NMS	6.58 ± 0.58	6.01 ± 0.75	0.57 ± 0.23		
2	PVI	5.69 ± 1.01	5.22 ± 0.81	0.47 ± 0.51	1.26 ± 0.62	0.80 ± 0.28
	CHX	5.44 ± 0.46	4.76 ± 0.54	0.68 ± 0.49	1.75 ± 0.48	1.08 ± 0.50
	NMS	6.23 ± 0.51	5.93 ± 0.41	0.30 ± 0.32	0.65 ± 0.41	0.35 ± 0.45
3	PVI	5.47 ± 0.59	4.95 ± 0.79	0.52 ± 0.58	1.53 ± 0.86	1.01 ± 0.71
	CHX	4.93 ± 0.82	3.66 ± 1.36	1.27 ± 1.19	2.85 ± 1.08	1.58 ± 0.79
	NMS	6.21 ± 0.40	5.86 ± 0.67	0.35 ± 0.48	0.72 ± 0.69	0.47 ± 0.52
4	PVI	5.09 ± 1.03	4.59 ± 0.75	0.50 ± 0.73	1.89 ± 0.78	1.40 ± 0.54
	CHX	5.12 ± 0.76	3.38 ± 1.44	1.75 ± 1.24	3.13 ± 1.22	1.39 ± 0.64
	NMS	6.29 ± 0.39	5.88 ± 0.39	0.41 ± 0.20	0.70 ± 0.45	0.29 ± 0.57
5	PVI	5.50 ± 0.78	5.10 ± 0.77	0.40 ± 0.42	1.39 ± 1.03	0.98 ± 0.97
	CHX	5.06 ± 0.57	4.12 ± 0.45	0.95 ± 0.51	2.39 ± 0.58	1.45 ± 0.61
	NMS	6.31 ± 0.31	5.81 ± 0.66	0.51 ± 0.42	0.77 ± 0.41	0.27 ± 0.47
8	PVI	6.56 ± 0.60	5.63 ± 1.13	0.92 ± 0.76	0.85 ± 1.04	-0.08 ± 0.83
	CHX	6.02 ± 0.38	4.50 ± 0.79	1.53 ± 0.92	2.02 ± 0.86	0.49 ± 0.52
	NMS	6.39 ± 0.42	6.05 ± 0.48	0.54 ± 0.28	0.53 ± 0.43	-0.01 ± 0.56

<sup>a</sup> C1, Count obtained on day 1 with the control hand (base line count).

<sup>a</sup> Cd, Count obtained from day 2 to day 8 with the control hand.

<sup>a</sup> T1, Count obtained on day 1 with the test hand.

<sup>a</sup> Td, Count obtained from day 2 to day 8 with the test hand.

<sup>a</sup> Mean ± standard deviation of log<sub>10</sub> number of microorganisms per hand.

TABLE 4. IE, CE, and RE of PVI, CHX, and NMS and comparison by Student's *t* test<sup>a</sup>

Scrub formulation and comparison	No. of subjects	IE (day 1)	CE (day 5)	RE (day 5)	RE (day 8)
PVI	49	0.94 ± 0.57	1.67 ± 0.78	0.99 ± 0.76	0.20 ± 0.74
CHX	35	1.08 ± 0.57	2.42 ± 0.81	1.33 ± 0.62	0.45 ± 0.58
NMS	41	0.62 ± 0.36	0.78 ± 0.55	0.39 ± 0.55	0.06 ± 0.49
NMS < PVI <sup>b</sup>		0.002	0.000	0.000	0.281
NMS < CHX <sup>b</sup>		0.000	0.000	0.000	0.008
PVI < CHX <sup>b</sup>		0.251	0.000	0.024	0.077

<sup>a</sup> Values are means ± standard deviation.

<sup>b</sup> Student's *t* test.

**Reviewer's Comments:** *This article mainly focused on describing a standardized method for evaluation of hand disinfection by various surgical scrub formulations. The aim of the study was to assess the validity of the protocol on the basis of statistical analysis and to compare the two antiseptic scrub formulations with each other and with the non-medicated soap. The authors concluded that the protocol described may be considered satisfactory for the comparison of scrub formulations because it allows comparisons between ineffective, bactericidal, and bactericidal plus remanent scrubs. Their analyses of data indicate that the population size required for further studies aimed at detecting significant differences between surgical scrub formulations could be estimated. There was no valuable information regarding the correlation of infection rates to the reduction of bacteria. The data were generated from nonrandomized, uncontrolled, and unblinded study. Demographics and disposition of the subjects were not provided (ratio of males to females and ages not described). The study does not describe the baseline determination. Normally baseline counts are performed in triplicate (days 1, 3, and 5) using a non-antimicrobial soap. The baseline count of the resident microbial populations is performed to evaluate eligibility of the study, as well as establish baseline values for each subject. Normally those subjects with baseline counts of at least  $1.5 \times 10^5$  organisms per hand are selected to continue the study. This article mentions that the mechanical effect of repeated scrubbing and bactericidal effect of the antiseptics differentially reduced hand flora, but the study was limited to a quantitative evaluation of the bacteria. Overall, there was no information regarding the correlation of infection rates to the reduction of bacteria and no clinical outcome data.*

**Grinbaum, RS, de Mendonca, JS, Cardo, DM. "An outbreak of handscrubbing-related surgical site infections in vascular surgical procedures." Infect Control Hosp Epidemiol 1995;16:198-202.**

The objective of the study reported in this publication was to investigate an outbreak of surgical site infections in vascular surgery unit related to handscrubbing with non-antimicrobial soap.

**DESIGNS & METHODS:** A 60-bed unit of vascular surgery, where surgeons performed an average of 30 operations per month at a 1,000-bed tertiary care hospital in Sao Paulo, Brazil. The study included in the case group nine patients who had limb amputations or arterial reconstructions from October 16 through 23, 1992. The study included in the control group patients (two controls for each case) whose operations were performed within 30 days of the outbreak period. Control patients were matched for sex and type of operation.

**RESULTS:** Six of nine case patients experienced surgical site infection, as compared with 3 of 18 control patients ( $P=0.026$ ) and 28 of 244 patients in the pre-epidemic period ( $P=0.0002$ ). The risk factors were balanced for case and control groups. Factors assessed were American Society of Anesthesiology status, duration of surgery, wound class, emergency status, remote site infections, preoperative length of stay, use of prophylactic antibiotics, and underlying diseases. Possible common sources also were analyzed. No differences were observed concerning hair removal, preoperative shower, wound dressing, and surgical team present in the operating room.

During the outbreak period, the operating room was not provided with povidone-iodine, used in the hospital for skin cleansing and handscrubbing. Surgeons from all departments, including vascular surgery, used 2% iodine with 70% alcohol for skin cleansing. Surgeons from other departments used this iodine solution for hand scrubbing, but the vascular surgeons used plain soap for handscrubbing. No increases in surgical site infection rates were reported in other services. Comparison of case and control groups for handscrubbing was statistically significant ( $P < 0.00001$ ). After reinstitution of povidone-iodine, only one surgical site infection was diagnosed in 13 vascular procedures. Overall, the conclusions drawn by the authors based on their analyses of data indicate that they could not demonstrate definitely that scrubbing with plain soap was related to surgical site infections, but they found a strong suggestion of this association.

**Reviewer's comments:** *Because of numerous deficiencies, the data presented is not able to demonstrate definitely that scrubbing with plain soap was related to surgical site infections. There were difficulties in the design of a case-control study in this outbreak because a small number of operations were studied and all patients were exposed to the suspected risk factor. Because of the unblinded nature of the study, bias cannot be ruled out. There was no description of the surgical hand scrubbing procedure that was used in the hospital. (how long the hands were scrubbed and how they were scrubbed). There were other risk factors to take in for consideration such as the presence of a particular surgeon, aseptic techniques, sterilization techniques, type of wound dressing applied etc... Overall, there was no valuable information regarding the correlation of infection rates to the reduction of bacteria.*

**Herruzo-Cabrera, R, Vizcaino-Alcide, MJ, and Fdez-Acinero, MJ. "Usefulness of an alcohol solution of n-duopropenide for the surgical antisepsis of the hands compared with handwashing with iodine-povidone and chlohexidine: clinical essay." J Surg Res 2000 (94):6-12.**

The objective of this study was to compare four alcohol solutions with the classic surgical handwashing products (chlorhexidine and iodine-povidone), in both *in vitro* and *in vivo* studies. The study was conducted to show that the usual surgical antisepsis involves scrubbing the skin with antiseptic solutions and this procedure can damage the skin, with the subsequent risk of infection for the patient. The authors discuss several efficient and quick-acting antiseptic alcohol solutions that require no scrubbing.

**DESIGN & METHODS:** Four alcohol solutions were compared with the classic surgical handwashing products (chlorhexidine and iodine-povidone), in both *in vitro* (pigskin germ carriers) and *in vivo* studies. *In vitro* studies were performed on lyophilized pig skin, cut in circles 0.5 cm in diameter, sterilized in steam flow, introduced into the culture medium with the tested germ, and left to grow on and between the skin trabeculae. Neutralizers were used and samples were taken and plated onto TBS agar. Multiresistant microorganisms were used. *In vivo* studies (clinical essays) were done with 15 healthy volunteers (crossed design) as well as with 154 surgical team members, whose hand microbial flora were measured before and after scrubbing up and after surgery.



**RESULTS:** Due to the efficiency in the germ carrier, N-duopropenide in 60% alcohol with emollients was chosen for further comparison with the standard surgical scrub: 4% chlorhexidine and 7.5% iodine-povidone. The quantitative, semi-quantitative, and qualitative results obtained with N-duopropenide without scrubbing were better in the healthy volunteers and surgical teams. This product reduced hand microorganisms by more than 2-log, and maintained the reduction for the entire study period. Four percent chlorhexidine initially reduced colonization more than 2-log but lost part of its effect over time during the surgical intervention. 7.5% iodine-povidone reduced the germs by 1 log but at the end of surgery there were even more germs than before washing.

***Reviewer's comments:** The authors concluded that scrubbing with classic antiseptic solutions should be replaced with gentle washing with an alcohol solution such as N-duopropenide in alcohol because of its efficacy, persistent effect, and skin protection. However, the study contains the following deficiencies: Demographics and disposition of the volunteers and surgical teams were not provided. No description of history of skin disease and whose hands were free of cuts, abrasions and disease. No description of whether the subjects were on antibiotics and/or oral contraceptives (causes an adverse effect on the microbial flora of the skin). The study was not blinded. No description of washout period. No description of scrub technique that was used. Overall, the information gathered from this study focused mainly on promoting the use of N-duopropenide in alcohol. The study was not designed to demonstrate a correlation between infection rates to the reduction of bacteria. There was no clinical relevance depicted in the study.*

**Larson, EL, Butz, AM, Gullette, DL, Laughon, BA. "Alcohol for surgical scrubbing?" Infect Control Hosp Epidemiol 1990 (11):139-143.**

The purpose of the study was to compare the immediate and sustained antimicrobial effectiveness and user acceptability of surgical scrub preparations containing either alcohol, triclosan, chlorhexidine gluconate or povidone iodine.

**DESIGN & METHODS:** Sixty healthy adult volunteers was selected who were not receiving systemic or topical antibiotics and who reported no history of skin disease or sensitivity to soaps. The subjects were assigned by block randomization (12 subjects per group) to use one of the following formulations: 70% ethyl alcohol with 0.5% chlorhexidine gluconate (ALC); a liquid detergent base containing 1% triclosan (TRI); a liquid detergent base containing 4% chlorhexidine gluconate (CHG); a liquid detergent base containing 7.5% povidone-iodine (PI); or a nonantimicrobial liquid soap (control). Using standard scrub protocol (ASTM method), subjects performed 5-minute surgical scrub daily for five consecutive days. Hand cultures were obtained at baseline and on test days 1 and 5 immediately after the scrub and following four hours of gloving.

**RESULTS:** After the first and last scrubs, ALC, CHG and PI resulted in significant reductions in colonizing flora when compared to the control. Additionally, by day 5 ALC was associated with an almost 3-log reduction as compared to an approximate 1.5-log reduction for CHG and PI and less than a 1-log reduction for TRI and the control ( $p = .009$ ). After 4 hours of gloving on both days 1 and 5, microbial counts on hands of

subjects using ALC, TRI and CHG were significantly lower than counts for the control (p less than .001), whereas there was no significant difference in counts between the PI and control groups (p = .41). None of the test products exceeded baseline on days 1 and 5. Skin assessment by study subjects rated products from least to most harsh as follows: control, TRI, CHG, ALC and PI p = .00001).

Mean Log Count (+ Standard Deviation) From Hands of 60 Subjects Using Surgical Scrub Protocol					
Active Ingredient	Baseline	After Scrub 1	After 4 hrs Gloving Day 1	After Scrub 5	After 4 hrs Gloving Day 5
Alcohol	6.04 (0.49)	4.06 (1.20)	4.83 (1.10)	3.19 (0.72)	3.62 (1.34)
Triclosan	5.84 (0.67)	5.28 (0.58)	5.39 (0.96)	5.28 (0.54)	5.69 (0.44)
Chlorhexidine	5.80 (0.58)	4.94 (0.95)	5.21 (1.10)	4.24 (0.63)	4.04 (1.11)
Povidone-Iodine	6.18 (0.39)	5.10 (0.47)	5.91 (0.46)	4.61 (0.49)	5.68 (0.31)
Control	6.07 (0.57)	5.68 (0.42)	6.06 (0.47)	5.65 (0.46)	6.29 (0.51)
ANOVA 5 groups	F:104 p .39	6.89 <.001	4.13 <.001	32.9 <.0001	23.3 <.0001

**Reviewer's comment:** The authors concluded that alcohol could be an efficacious and acceptable alternative for surgical scrubbing. There were numerous deficiencies in the studies. There was limited description regarding the use of neutralizers in the samples. No description about neutralization validation was provided. Subjects using oral contraceptives (causes an adverse effect on the microbial flora of the skin) were not excluded. Demographics and disposition of the participants were not provided. The study was not blinded. The study contained a small sample size of subjects. Only a 3-day washout period was conducted. Only a single baseline count was determined in the study. Normally baseline counts are performed in triplicates (days 1, 3, and 5) using a non-antimicrobial soap. The baseline count of the resident microbial populations is performed to evaluate eligibility of the study, as well as establish baseline values for each subject. Normally those subjects with baseline counts of at least  $1.5 \times 10^5$  organisms per hand are selected to continue the study. Hand sampling was not randomized. There was no valuable information regarding the correlation of infection rates to the reduction of bacteria. There was no clinical relevance depicted in the study.

**Maki DG. "The use of antiseptics for handwashing by medical personnel." Chemother 1989 (1):3-11.**

This review article describes various studies that have shown that the major reservoir of nosocomial infection in the hospital is the infected or colonised patient and the major mode of spread of organisms between patients is on the hands of medical personnel.

Hygienic handwashing in the hospital or clinic, to remove transient contaminants acquired from patients or the environment and prevent cross-infection to vulnerable patients, is similarly regarded as one of the most fundamental infection control measures, yet is done infrequently by personnel in most hospitals. Following a typical brief (7.10

second) handwashing with a nonmedicated soap, the number of organisms that can be transmitted from the person's hands may, paradoxically, actually increase. Use of chlorhexidine for handwashing or application of an evaporative alcohol-based lotion has been found to reduce shedding of bacteria-laden skin squames. Routine use of antiseptic-containing handwashing agents is clearly more effective than nonmedicated soaps for microbial removal, enhancing the value of the handwashings and possibly protecting against contaminants acquired between handwashings. In a sequential comparative trial of three handwashing agents in a surgical intensive care unit--a nonmedicated soap, 10% povidone-iodine solution, and 4% aqueous chlorhexidine, each used exclusively for approximately six weeks the incidence of nosocomial infection was 50% lower during the use of the antiseptic handwashing products than during the use of nonmedicated soap ( $P$  less than .001). Novel approaches are needed to improve the frequency of hygienic handwashing.

***Reviewer's comment:** The author concludes that the advances in hand degerming could substantially reduce the incidence of nosocomial infection. This article gives a historical review on various handwashing studies. There was no valuable information regarding the correlation of infection rates to the reduction of bacteria. There was no clinical relevance depicted in the study.*

**Morrison, AJ, Gratz, J, Cabezudo, I, Wenzel, R. "The efficacy of several new handwashing agents for removing non-transient bacterial flora from hands." Infect Control 1986 (7):268-72.**

This article describes several new handwash agents for efficacy in removing non-transient flora from the hands of medical personnel using the sterile bag technique of quantitative hand culture after brief contact times, while incorporating an effective handwash agent neutralizer.

**DESIGN & METHODS:** Forty subjects participated in a study of six handwashing agents evaluated for their efficacy in removing non-transient bacteria: 70% isopropanol, 0.05% stabilized iodine, 4% chlorhexidine gluconate, 1% para-chloro-meta-xyleneol, 0.5% chlorohexidine gluconate, and 60% isopropyl alcohol with emollients. Phase one of the study involved each subject using a non-medicated handwash to remove transient flora. Afterwards, three consecutive experimental handwashes were performed using a 10-second contact time, and a fourth handwash employed a 1-minute contact time. Quantitative post-handwash cultures were obtained using the sterile bag technique incorporating an effective agent neutralizer. Phase two of the study involved obtaining subject's baseline bacterial flora. Then four consecutive agent applications were performed. Hand culturing was performed between each agent application using a sterile bag technique. After culturing, a tapwater rinse without friction was performed to eliminate residual broth, and then the hands were air-dried without friction prior to the next application of agent.

**RESULTS:** Significant mean log<sub>10</sub> reductions were documented for chlorhexidine gluconate, but only after the third ( $P = .05$ ) and fourth ( $p = .004$ ) handwash. However, the total log<sub>10</sub> reduction was less than 1.0 for any single agent. Subsequently, three evaporative handwash agents, including 70% isopropanol, 0.5% chlorhexidine in 70%

isopropanol, and a 60% isopropanol formulation containing evaporative retardants, were tested in 14 subjects. Contact time was prolonged to the point of evaporation prior to culturing. Four consecutive post-handwash cultures were obtained after performing a baseline pre-handwash culture. When compared with the other two evaporative agents, the 60% isopropanol formulation demonstrated significant mean log<sub>10</sub> reductions for each handwash (p less than or equal to .03), with a total log<sub>10</sub> reduction of 2.9 over all four handwashes (p = .0001).

Table 1.

Inter-agent comparisons of mean log<sub>10</sub> bacterial reduction / mean after each of four consecutive handwashes with four handwashing agents (N=40)

Handwash Number	MLR IA	MLR AK	MLR IK	MLR HC
1	0.05	0.15	0.12	0.19
2	0.17	0.23	0.12	0.21
3	0.07	0.11	0.08	0.25*
4	0.04	0.14	0.06	0.29†
Total (1-4)	0.33	0.63	0.38	0.94‡

\*p=0.05; HC more efficacious than IA/AK/IK

†p=0.004; HC more efficacious than IA/AK/IK

‡p=0.0001; HC more efficacious than IA/AK/IK

Key:

IA=70% isopropyl alcohol with 1% glycerin

AK=Acute-Kare; 1% PCMX; Calgon Corporation, St.Louis, MO.

IK=Ido-Kare; 0.05% stabilized iodine; Calgon Corporation, St. Louis, MO.

HC=Hibiclens; 4% Chlorhexidine gluconate; Stuart Pharmaceuticals

Table 2.

Inter-agent comparisons of mean log<sub>10</sub> bacterial reduction (MLR) after each of four consecutive handwashes with three evaporative handwashing agents (N=14)

Handwash Number	MLR IA	MLR HS	MLR CS
1	-0.5	- 0.15	1.4*
2	0.3	0.0	0.5†
3	0.0	0.1	0.5
4	0.2	0.0	0.5**
Total (1-4)	0.0	-0.3	2.9††

\*p=0.0001; CS more efficacious than IA/HS

†p=0.02; CS more efficacious than IA/HS

‡p=0.03; CS more efficacious than IA/HC

\*\*p=0.0001; CS more efficacious than IA/HC

Key:

IA=70% isopropyl alcohol with 1% glycerin

HS=0.5% chlorhexidine gluconate in 70% isopropyl alcohol; Stuart Pharmaceuticals, Wilmington, DE

CS=60% isopropyl alcohol with evaporative retardants; Calgon Corporation, St. Louis, MO

HC=Hibiclens; 4% Chlorhexidine gluconate; Stuart Pharmaceuticals

**Reviewer's comment:** *The authors concluded that data from this study do not imply any agent preference for the reduction of non-transient flora with the possible exception of 60% isopropyl alcohol. The authors also suggest that further studies are needed to substantiate the importance of non-transient bacteria in nosocomial infections. No description of the type of neutralizers that were used. No description of washout period was conducted. There were no demographics and disposition of the subjects provided. The study contained a small sample size of subjects. There was no mention of the exclusion criteria of subjects admitted into the study including use of topical or systemic antimicrobials, or any other medication (such as oral contraceptives) known to affect the normal flora of the skin. There was no blinding of test formulations. There was no valuable information regarding the correlation of infection rates to the reduction of bacteria. There was no clinical relevance depicted in the study.*

**O'Farrell, DA, Kenny, G, O'Sullivan, M, Nicholson, P, Stephens, M, and Hone, R.** "Evaluation of the optimal hand-scrub duration prior to total hip arthroplasty." *J Hosp Infect* 1994 (26):93-98.

This objective of this study was to re-assess the antimicrobial efficacy of two different scrub durations that are applicable to orthopaedic practice in view of the increased use of power instrumentation and manual exertion.

**DESIGN & METHODS:** The study evaluated the antimicrobial efficacy of a 5 min compared with a 10 min scrub before both long (> 90 min) and short (< 90 min) operations for total hip arthroplasty. Orthopaedic surgeons in many major arthroplasty centers advocate the use of a prolonged surgical hand-scrub prior to total joint replacement. Surgical hand disinfection was performed on one occasion for 5 min and on a second for 10 min by 41 surgeons and theatre nurses using 4% chlorhexidine gluconate as a detergent formulation ('Hibiscrub', ICI Pharmaceuticals). None of the subjects had previously scrubbed on the day of each test. Bacterial colony counts on the fingers were measured using the method described by Rotter (vide infra) before scrubbing, immediately after scrubbing, and at the end of each operation.

**RESULTS:** The results showed that for arthroplasty procedures lasting less than 90 min (35 operations), a 5 min hand-scrub was equally as effective as one of 10 min. However, following longer procedures (36 operations) colony counts were significantly higher on subjects who had scrubbed for 10 min than on those who only scrubbed for 5 ( $P < 0.05$ , Mann-Whitney U-Test).

**Reviewer's comments:** *The authors suggest that the practice of a prolonged scrub before total joint replacement does not have a scientific basis and that such a policy should be discontinued where it is still practiced. The study was not a clinical trial designed study. There were 13 glove perforations found in 82 operations, 9 of which occurred in operations under 90 min and 4 in operations over 90 min in duration. There was no mention if there were any surgical site infections. There was no valuable information regarding the correlation of infection rates to the reduction of bacteria.*

**Parienti JJ, Thibon P, Heller R, LeRoux Y, von Theobald P, Bensadoun H, Bouvet A, Lemarchand F, Le Coutour X. "Hand-rubbing with an aqueous alcoholic solution vs traditional surgical hand-scrubbing and 30-day surgical site infection rates." JAMA 2002 (288):722-727.**

The purpose of this study was to compare the effectiveness of hand-cleansing protocols in preventing surgical site infections during routine surgical practice.

**DESIGNS & METHODS:** Randomized equivalence trial comparing hand-scrubbing and hand-rubbing protocols with a multiple service crossover experimental design. Six surgical services from teaching and nonteaching hospitals in France included a total of 4387 consecutive patients who underwent clean and clean-contaminated surgery between January 1, 2000, and May 1, 2001. Surgical services used 2 hand-cleansing methods alternately every other month: a hand-rubbing protocol with 75% aqueous alcoholic solution containing propanol-1, propanol-2, and mecetronium etilsulfate; and a hand-scrubbing protocol with antiseptic preparation containing 4% povidone iodine or 4% chlorhexidine gluconate. Thirty-day surgical site infection rates were the primary end point; operating department teams' tolerance of and compliance with hand antisepsis were secondary end points. A non-medicated soap was used in conjunction with the first wash of the day and also when the hands were visibly soiled. Surgical site infections were prospectively diagnosed by a surgeon, infectious disease specialist, or hygiene specialist on a standard data-collection form. Post-discharge surveillance was based on chart review of visits and telephone contacts with the surgeons.

**RESULTS:** The two protocols were comparable in regard to surgical site infection risk factors. The Table below shows that the surgical site infection rates were 55 of 2252 (2.44%) in the hand-rubbing protocol and 53 of 2135 (2.48%) in the hand-scrubbing protocol, for a difference of 0.04% (as treated 95% confidence interval, -0.88% to 0.96%). During the study period, 278 individual compliance assessments were made of the operating teams (174 in the hand-rubbing group), corresponding with 160 surgical procedures (102 in the hand-rubbing group). On the average, the first hand-cleansing protocol of the day, excluding the simple non-antiseptic hand wash prior to hand-rubbing, lasted significantly longer in the hand-rubbing group than in the hand-scrubbing group (mean [SD], 313 [80] seconds vs 287 [75] seconds;  $P=.01$ ). Scrub nurses complied better with the recommended duration of hand antisepsis than did surgeons and assistants (56% vs 33%;  $P<.001$ ). Based on subsets of personnel, compliance with the recommended duration of hand antisepsis was better in the hand-rubbing protocol of the study compared with the hand-scrubbing protocol (44% vs 28%, respectively;  $P=.008$ ), as was tolerance, with less skin dryness and less skin irritation after aqueous solution use.

**Table 2. Surgical Site Infection (SSI) Rates and Differences Between Hand-Scrubbing and Hand-Rubbing\***

Atteimer Class of Contamination	No. SSI/No. Operations (%)		SSI Rate Difference (Hand-Scrubbing–Hand-Rubbing), % (95% Confidence Interval)	$\chi^2$ Test of Equivalence (P Value)
	Hand-Scrubbing Protocol	Hand-Rubbing Protocol		
Clean	29/1485 (1.95)	32/1520 (2.11)	–0.15 (–1.16 to 0.85)	16.0 (<.001)
Clean-contaminated	24/650 (3.69)	23/732 (3.14)	0.55 (–1.36 to 2.46)	1.9 (.09)
All	53/2135 (2.48)	55/2252 (2.44)	0.04 (–0.88 to 0.96)	19.5 (<.001)

\*The 95% confidence interval of the SSI rate difference was calculated according to Wallenstein<sup>18</sup> and the  $\chi^2$  test was the lowest  $\chi^2$  value of the Dunnett and Gent<sup>19</sup> continuity corrected double 1-sided test for equivalence at –2% and +2%.

**Table 3. Compliance With the Recommended Duration of Hand Antisepsis During the First Procedure of the Day\***

Operating Room Personnel	Hand-Scrubbing Protocol	Hand-Rubbing Protocol	P Value†
Duration of hand antisepsis, mean (range), s	287 (100-480)	313 (60-510)	.01‡
No. of hand antisepsis ≥5 min/total no. of hand antisepsis (%)			
Surgeon/assistant	20/83 (24)	51/133 (38)	.04
Scrub nurse	9/21 (42)	26/41 (63)	.18
All	29/104 (28)	77/174 (44)	.008

\*Time required for the nonantiseptic hand wash prior to hand rubbing with aqueous alcoholic solution has been excluded.

†Analyzed using Fisher exact test.

‡Analyzed using Mann-Whitney test.

**Reviewer's Comments:** What the study shows, despite its deficiencies is that 75% alcoholic solution (propanol-1, propanol-2 and mecetronium etilsulfate) with PVP-I and CHG in actual surgical situations showed no statistical difference in the surgical site infection rates. This is the first randomized trial to compare hand-rubbing with alcohol-based solution with traditional hand-scrubbing in the routine surgical setting. The authors mention that according to CDC guidelines, all surgical site infections had to be confirmed by the surgeon or the physician in charge of the patient. Therefore, observers of the clinical outcome could not be blinded to the hand antisepsis protocol. Because of the unblinded nature of the study, bias cannot be ruled out. There was no description on how the patients were cared for after the operation, details on health of the patients, or antibiotics use before undergoing surgical procedures. There was no microbiological evaluation of SSI on the patients. It would be difficult to link the source of infection to the surgeon. There were no reports of glove tears or punctures. Other risk factors such as aseptic techniques, sterilization of surgical instruments used, type of wound dressing applied etc...were not considered. In conclusion, the trial does not provide absolute evidence correlating clinical outcome of infection rates to the reduction of bacteria on the surgeon's hands.

**Pereira LJ, Lee GM, and Wade KJ. “The effects of surgical handwashing routines on the microbial counts of operating room nurses.” Am J Infect Control 1990 (18):354-364.**

The objective of the study reported in this publication was to determine whether a shorter duration surgical scrub achieves the same reductions in colony forming units (CFU) as a standard scrub.

**DESIGNS & METHODS:** This study examined two interdependent factors: the time taken to wash the hands and the type of antiseptic solution used. A 3-minute initial scrub and 30-second consecutive scrub regimen was compared with a current standard regimen of a 5-minute initial scrub and a 3-minute consecutive scrub. Chlorhexidine gluconate 4% and povidone-iodine 7.5% were the antiseptics used in the two regimens. The sample (n = 34) was drawn from nurses employed in the operating room suite of a 950-bed hospital.

**RESULTS:** Chlorhexidine gluconate was found to be responsible for lower numbers of colony-forming units of bacteria than povidone-iodine. The duration of the scrub had no significant effect on the numbers of bacteria when povidone-iodine was used. The optimal regimen was found to be the 5-minute initial and 3-minute consecutive scrubs with chlorhexidine gluconate.

***Reviewer’s Comments:** The authors analyses of data indicate that although the shorter-duration surgical scrub is apparently adequate with either of the scrub antiseptics tested, the longer-duration surgical scrub with chlorhexidine gluconate achieves and maintains the best microbial reductions. The study did not provide any demographics and disposition of the subjects. The study contained small sample size of subjects. A washout period of one week was included but subjects were instructed to continue normal handwashing procedures during this period. There was no information regarding blinding of the test materials and those analyzing the data. There was no use of a baseline non-antimicrobial control soap. No description of neutralization validation was provided. There was a significant difference between hand counts which made it necessary to calculate predicted microbial counts. Overall, the information gathered from this study focused mainly on comparing two surgical hand disinfectants povidone iodine and chlorhexidine gluconate and the optimal scrub time. There was no valuable information regarding the correlation of infection rates to the reduction of bacteria. There was no clinical relevance depicted in the study.*

**Pereira, LJ, Lee, GM, and Wade, KJ. “An evaluation of five protocols for surgical handwashing in relation to skin condition and microbial counts.” J Hosp Infect 1997 (36):49-65.**

The purpose of this study was to (1) determine whether a shorter duration surgical scrub protocol with a variety of antiseptics can achieve the same reductions in microbial numbers as a more conventional (5 min duration) method with 4% CHG and (2) determine whether a reduction in the duration of the surgical scrub would result in improved skin condition assessments.



**DESIGN & METHODS:** Five protocols for surgical handwashing (scrubbing) were evaluated for their efficiency of removal of micro-organisms and their drying effect on the skin. The scrubbing protocols tested were: (1) an initial scrub of 5 min and consecutive scrubs of 3.5 min with chlorhexidine gluconate 4% (CHG-5); (2) an initial scrub of 3 min and consecutive scrubs of 2.5 min with chlorhexidine gluconate 4% (CHG-3); (3) an initial scrub of 3 min and consecutive scrubs of 2.5 min with povidone iodine 5% and triclosan 1% (PI-3); (4) an initial scrub of 2 min with chlorhexidine gluconate 4% followed by a 30 s application of isopropanol 70% and chlorhexidine gluconate 0.5%, and a 30 s application of isopropanol 70% and chlorhexidine gluconate 0.5% for consecutive scrubs (IPA); and (5) an initial scrub of 2 min with chlorhexidine gluconate 4% followed by a 30 s application of ethanol 70% and chlorhexidine gluconate 0.5%, and a 30 s application of ethanol 70% and chlorhexidine gluconate 0.5% for consecutive scrubs (EA). A convenience sample of 23 operating theatre nurses completed each scrub protocol for one week in a randomized order. A week of normal work activities intervened between each protocol. Subjects were assessed before commencing and after completing the week of each protocol to determine changes in the microbial counts and skin condition of the hands. Specimens for microbial analysis were collected before, immediately after and 2 h after an initial scrub, and 2 h after a consecutive scrub. The CHG-5, CHG-3 and PI-3 protocols, which used detergent-based antiseptics only, were compared with protocols incorporating an alcohol-based antiseptic (IPA and EA). The protocols incorporating alcohol-based antiseptics and the CHG-5 protocol were generally associated with the lowest post-scrub numbers of cfu.

**RESULTS:** No difference between the CHG-5 protocol and the alcohol-based antiseptics was found at the beginning of the test week, but after exclusive use of the respective protocols for a week, the alcohol-based antiseptics were associated with significantly lower cfu numbers in two out of the three post-scrub samples ( $P = 0.003$ ,  $P = 0.035$ ). Although virtually no statistically significant differences in skin condition were found, many subjects reported the alcohol-based antiseptic protocols to be less drying on the skin.

*Reviewer's comments: The authors of this study support the proposition that a scrub protocol using alcohol-based antiseptics is as effective and no more damaging to skin than more time-consuming, conventional methods using detergent-based antiseptics. There was no information regarding blinding of the test materials and those analyzing the data. The ratio of males to females subjects were 5:27. There was no use of a baseline non-antimicrobial control soap. No description of neutralization validation was provided. Overall, the information gathered from this study focused mainly on comparing surgical hand disinfectants and the optimal scrub time. There was no valuable information regarding the correlation of infection rates to the reduction of bacteria. There was no clinical relevance depicted in the study.*

**Poon, C, Morgan, DJ, Pond, F, Kane, J, Tulloh BR. Studies of the surgical hand scrub. Aust NZ J Surg 1998;68:65-67.**

This study was designed to evaluate the effectiveness of various scrub techniques in reducing bacterial skin flora.

**DESIGN & METHODS:** The study design was developed in three stages. Each stage involved fingertip bacterial colony counts measured before, immediately after and 30 minutes after a variety of handwashing techniques using 10% povidone iodine solution. The first compared 1, 2, or 3 non-timed washes from fingertips to elbows in 10 volunteers. The second compared two volunteers scrubbing for equal durations with or without friction rubbing, while the third involved 15 volunteers who each scrubbed for different time intervals. Volunteers rotated through each of the three techniques on separate days. Precise handwashing times were not recorded, but a single pass usually took between 20 and 45 seconds. A scrubbing brush was not used. After washing with disinfectant, volunteers dried their hands on a sterile cloth towel and then made fingertip impressions on an agar plate to provide the immediate post-scrub colony count. A sterile gown and gloves were then donned. After 30 minutes the gloves were removed and fingertip cultures were performed. The agar plates were then incubated at 37°C for 48 hours to colony counting by one individual who was blinded to the handwashing process.

**RESULTS:** There was considerable variation seen in the pre-scrub colony counts between individuals and, to a lesser extent, for the same individual on different days. The organisms cultured were similar to those seen in other studies, and comprised mixed skin flora including coagulase-negative staphylococci, coliforms, and micrococci. The first stage showed that a single wash episode failed to provide lasting bacterial colony count reductions on fingertip cultures. The second showed that enduring colony count reductions occur whether friction rubbing of the hands was used or not, and the third showed that a 30 second wash was as effective as washing for longer periods in reducing fingertip flora.

*Reviewer's Comments: Fingerprint technique method was used in this study. The authors conclude that prolong vigorous pre-operative scrubbing is unnecessary, although more than a cursory wash is required to produce lasting fingertip antiseptis. The study contained a small sample size of subjects. Demographics and disposition of the subjects were not provided. No washout period. The study was not blinded. This was not a clinical trial design study. Overall, the information gathered from this study focused mainly on scrub time. The study was not designed to demonstrate a correlation between infection rates to the reduction of bacteria. There was no clinical relevance depicted in the study.*

**Rehork, B and Ruden, H. "Investigations into the efficacy of different procedures for surgical hand disinfection between consecutive operations." J Hosp Infect 1991 (19):115-127.**

In order to examine whether thorough surgical hand disinfection (handwashing plus hand disinfection) between consecutive operations is necessary, tests were carried out simulating normal clinical conditions.

**DESIGN & METHODS:** The tests were performed according to the guidelines for the evaluation of disinfection procedures of the German Society for Hygiene and Microbiology. Surgical hand disinfection was as follows: handwashing with soap without antimicrobial additives and subsequent 5-min disinfection with 60% n-propanol. This

was followed by simulated operations of 30 or 120 min duration with a 30-min break between operations, during which half of the test group kept on the surgical gloves, while the other half removed them. The second surgical hand disinfection was done without prior handwashing by 50% of the test group. The disinfection time was reduced from 5 to 1 min by 50% of the test group.

**RESULTS:** The results were evaluated by means of explorative data analysis and inductive statistical methods. Removing the surgical gloves during the interoperative break did not result in significantly higher numbers of colony forming units (cfu) compared with retaining the gloves. This was also the case after a subsequent handwashing. At the second surgical hand disinfection, after a simulated operation of 60 min duration (including break), there was no significant difference in the numbers of cfus between the test group who had washed their hands and those who had not. Reducing the disinfection time from 5 min to 1 min was not associated with a significant increase in the number of cfus. However, after a simulated operating time of 150 min (including the break), the second surgical hand disinfection with handwashing resulted in a significantly lower number of microorganisms than disinfection alone. In half the tests, the numbers of cfu were significantly lower when the test group disinfected their hands for 5 min rather than 1 min.

***Reviewer's comments:** The authors concluded that wearing surgical gloves during the interoperative break does not result in any microbiological advantages. The cfu numbers on the hands were not significantly lowered by wearing surgical gloves during the interoperative break. There were limitations in the study. Washout period was only for three days. Two weeks are required in the TFM. Demographics and disposition of the subjects were not provided. No description of whether subjects were using antibiotics and/or oral contraceptives (causes an adverse effect on the microbial flora of the skin) were included in the study. No description if neutralizers were used. There was no description of whether sampling was randomized. There was no valuable information regarding the correlation of infection rates to the reduction of bacteria. There was no clinical relevance depicted in the study.*

## **Conclusion**

Overall, based on the literature reviewed, the reviewers from the Healthcare Antiseptic Working Group found no evidence of a direct link between bacterial log reduction and decreased hospital infection rates pertaining the use of surgical hand scrubs. Most of the literature reviewed, have a number of confounding issues, such as lack of double blind controlled studies, randomizations, baseline recovery, statistical designs and analyses, various methods of surgical hand scrub technique methods, and use of neutralization. Additional research is needed to determine the appropriate surrogate endpoints to be used for surgical hand scrub drug products. However, the current endpoints established in the 1994 TFM criteria for surgical hand scrubs should remain standing until a valid clinical trial design is conducted. Currently the FDA has approved over 20 New Drug Applications (NDAs) based on the surrogate endpoints described in the TFM.

Michelle M. Jackson, Ph.D.  
Microbiology Reviewer  
Division of Over-the-Counter Drug Products

Concurrence:

John H. Powers, M.D.  
Medical Officer, Team Leader  
Office of Drug Evaluation IV

## References

- Boyce, JM, Potter-Bynoe, G, Opal, SM, Dziobek L, and Medeiros, AA. "A common source outbreak of Staphylococcus epidermidis infections among patients undergoing cardiac surgery." *J Infect Dis* 1990 (161):494-499.
- Bryce, EA, Spence, D, and Roberts, F. "An in-use evaluation of an alcohol-based pre-surgical hand disinfectant." *Infect Control Hosp Epidemiol* 2001 (22):635-639.
- Cremieux, A, Reverdy, ME, Pons, JL, Savage, C, Chevalier, J, Fleurette, J, Mosse, M. Standardized method for evaluation of hand disinfection by surgical scrub formulations. *Appl Environ Microbiol* 1989;55:2944-2948.
- Grinbaum, RS, de Mendonca, JS, Cardo, DM. An outbreak of handscrubbing-related surgical site infections in vascular surgical procedures. *Infect Control Hosp Epidemiol* 1995;16:198-202.
- Herruzo-Cabrera, R, Vizcaino-Alcide, MJ, and Fdez-Acinero, MJ. "Usefulness of an alcohol solution of n-duopropenide for the surgical antisepsis of the hands compared with handwashing with iodine-povidone and chlohexidine: clinical essay." *J Surg Res* 2000 (94):6-12.
- Larson, EL, Butz, AM, Gullette, DL, Laughon, BA. "Alcohol for surgical scrubbing?" *Infect Control Hosp Epidemiol* 1990 (11):139-143.
- Maki DG. "The use of antiseptics for handwashing by medical personnel." *Chemother* 1989 (1):3-11.
- Morrison, AJ Morrison, AJ, Gratz, J, Cabezudo, I, Wenzel, R. "The efficacy of several new handwashing agents for removing non-transient bacterial flora from hands." *Infect Control* 1986 (7):268-72.
- O'Farrell, DA, Kenny, G, O'Sullivan, M, Nicholson, P, Stephens, M, and Hone, R. "Evaluation of the optimal hand-scrub duration prior to total hip arthroplasty." *J Hosp Infect* 1994 (26):93-98.
- Parienti JJ, Thibon P, Heller R, LeRoux Y, von Theobald P, Bensadoun H, Bouvet A, Lemarchand F, Le Coutour X. "Hand-rubbing with an aqueous alcoholic solution vs traditional surgical hand-scrubbing and 30-day surgical site infection rates." *JAMA* 2002 (288):722-727.
- Pereira, LJ, Lee, GM, and Wade, KJ. "An evaluation of five protocols for surgical handwashing in relation to skin condition and microbial counts." *J Hosp Infect* 1997 (36):49-65.

Pereira LJ, Lee GM, and Wade KJ. "The effects of surgical handwashing routines on the microbial counts of operating room nurses." *Am J Infect Control* 1990 (18):354-364.

Poon, C, Morgan, DJ, Pond, F, Kane, J, Tulloh BR. Studies of the surgical hand scrub. *Aust NZ J Surg* 1998;68:65-67.

Rehork, B and Ruden, H. "Investigations into the efficacy of different procedures for surgical hand disinfection between consecutive operations." *J Hosp Infect* 1991 (19):115-127.

## APPENDIX I

1. ADA Division of Science on behalf of the ADA Council on Scientific Affairs. "Antiseptic antimicrobial hand washes." *J Am Dent Assoc.* 2003 Jul;134(7):906-7.
2. Aly R, Maibach HI. "Comparative antibacterial efficacy of a 2-minute surgical scrub with chlorhexidine gluconate, povidone-iodine, and chloroxylonol sponge-brushes." *Am J Infect Control.* 1988 Aug;16(4):173-7.
3. Aly R, Maibach HI. "Comparative evaluation of chlorhexidine gluconate (Hibiclens) and povidine-iodine (EZ Scrub) sponge/brushes for pre surgical hand scrubbing." *Curr Therap Res.* 1983 (34): 740-745.
4. Aly R, Maibach HI. "Comparative study on the antimicrobial effect of 0.5% chlorhexidine gluconate and 70% isopropyl alcohol on the normal flora of hands." *Appl Environ Microbiol.* 1979 (37):610-613.
5. Ansari SA, Sattar SA, Springthorpe VS, Wells GA, Tostowaryk W. "In vivo protocol for testing efficacy of hand-washing agents against viruses and bacteria: experiments with rotavirus and Escherichia coli." *Appl Environ Microbiol.* 1989 Dec;55(12):3113-8.
6. Association of periOperative Registered Nurses Recommended Practices Committee. "Recommended practices for surgical hand antisepsis/hand scrubs." *AORN J.* 2004 Feb;79(2):416-8, 421-6, 429-31.
7. Ayliffe GA, Babb JR, Davies JG, Newsom SW, Rowland C, Platt JH, Mason B. "Hygienic hand disinfection tests in three laboratories." *J Hosp Infect.* 1990 Aug;16(2):141-9.
8. Ayliffe GA, Babb JR, Davies JG, Lilly HA. "Hand disinfection: a comparison of various agents in laboratory and ward studies." *J Hosp Infect.* 1988 Apr;11(3):226-43.
9. Ayliffe GA. "Surgical scrub and skin disinfection." *Infect Control.* 1984 Jan;5(1):23-7.
10. Ayliffe GAJ, Babb JR, Bridges K, Lilly HA, Lowbury EJJ, Varney J, Wilkins MD. "Comparison of two methods for assessing the removal of total organisms and pathogens from the skin." *J Hyg Camb.* 1975 (75):259-74.
11. Babb JR, Davies JG, Ayliffe GA. "A test procedure for evaluating surgical hand disinfection." *J Hosp Infect.* 1991 Jun;18 Suppl B:41-9.
12. Baker KA, McGarigle C, Bodman H, Rapoport JM. "Comparative analysis: 4% chlorhexidine gluconate versus 7.5% povidone-iodine surgical scrubs in bone marrow transplant recipients." *Prog Clin Biol Res.* 1985;181:443-6.
13. Bannan EA. "Surgical scrub degerming. The effect of personal bar soaps." *Ohio State Med J.* 1967 Oct;63(10):1322-4.

14. Baquero F, Patron C, Canton R, Martinez Ferrer M. "Laboratory and in-vitro testing of skin antiseptics: a prediction for in-vivo activity?" *J Hosp Infect.* 1991 Jun;18 Suppl B:5-11.
15. Barrau K, Rovey C, Drancourt M, Brouqui P. "Hand antisepsis: evaluation of a sprayer system for alcohol distribution." *Infect Control Hosp Epidemiol.* 2003 Mar;24(3):180-3.
16. Bartzokas CA, Corkill JE, Makin T, Parry E. "Comparative evaluation of the immediate and sustained antibacterial action of two regimens, based on triclosan- and chlorhexidine-containing handwash preparations, on volunteers." *Epidemiol Infect.* 1987 Jun;98(3):337-44.
17. Bartzokas CA, Corkill JE, Makin T. "Evaluation of the skin disinfecting activity and cumulative effect of chlorhexidine and triclosan handwash preparations on hands artificially contaminated with *Serratia marcescens*." *Infect Control.* 1987 Apr;8(4): 163-7.
18. Bartzokas CA, Corkill JE, Makin T, Pinder DC. "Assessment of the remanent antibacterial effect of a 2% triclosan-detergent preparation on the skin." *J Hyg (Lond).* 1983 Dec;91(3):521-8.
19. Bartzokas CA, Gibson MF, Graham R, Pinder DC. "A comparison of triclosan and chlorhexidine preparations with 60 percent isopropyl alcohol for hygienic hand disinfection." *J Hosp Infect.* 1983 Sep;4(3):245-55.
20. Beck WC. "The merits of alcohol as a skin degerming agent." *Infect Control.* 1985 Jan;6(1):4.
21. Beeuwkes H, de Rooij SH. "Microbiological tests on operating-theatre staff of a new disinfectant foam based on 1% chlorhexidine gluconate." *J Hosp Infect.* 1986 Sep;8(2):200-2.
22. Bellamy K, Alcock R, Babb JR, Davies JG, Ayliffe GA. "A test for the assessment of hygienic hand disinfection using rotavirus." *J Hosp Infect.* 1993 Jul;24(3):201-10.
23. Bendig JW. "Surgical hand disinfection: comparison of 4% chlorhexidine detergent solution and 2% triclosan detergent solution." *J Hosp Infect.* 1990 Feb;15(2):143-8.
24. Benson L, Bush L, LeBlanc D. "Importance of neutralizers in the stripping fluid in a simulated healthcare personnel handwash." *Infect Control Hosp Epidemiol.* 1990 Nov;11(11):595-9.
25. Benson L, LeBlanc D, Bush L, White J. "The effects of surfactant systems and moisturizing products on the residual activity of a chlorhexidine gluconate handwash using a pigskin substrate." *Infect Control Hosp Epidemiol.* 1990 Feb;11(2):67-70.
26. Berman M. "One hospital's clinical evaluation of brushless scrubbing." *AORN J.* 2004 Feb;79(2):349-54, 357-8.



27. Berry AR, Watt B, Goldacre MJ, Thomson JW, McNair TJ. "A comparison of the use of povidone-iodine and chlorhexidine in the prophylaxis of postoperative wound infection." *J Hosp Infect.* 1982 Mar;3(1):55-63.
28. Bertrand X, Bailly P, Blasco G, Balvay P, Boillot A, Talon D. "Large outbreak in a surgical intensive care unit of colonization or infection with *Pseudomonas aeruginosa* that overexpressed an active efflux pump." *Clin Infect Dis.* 2000 Oct;31(4):E9-E14. Epub 2000 Oct 25.
29. Bettin K, Clabots C, Mathie P, Willard K, Gerding DN. "Effectiveness of liquid soap vs. chlorhexidine gluconate for the removal of *Clostridium difficile* from bare hands and gloved hands." *Infect Control Hosp Epidemiol.* 1994 Nov;15(11):697-702.
30. Bhargava HN, Leonard PA. "Triclosan: applications and safety." *Am J Infect Control.* 1996 Jun;24(3):209-18.
31. Birnbaum D. "Report on chloroxylonol-containing antiseptic: reference correction." *Infect Control.* 1986 Nov;7(11):532.
32. Bischoff WE, Reynolds TM, Sessler CN, Edmond MB, Wenzel RP. "Handwashing compliance by healthcare workers: The impact of introducing an accessible, alcohol-based hand antiseptic." *Arch Intern Med.* 2000 Apr 10;160(7):1017-21.
33. Blech MF, Hartemann P, Paquin JL. "Activity of non antiseptic soaps and ethanol for hand disinfection." *Zentralbl Bakteriol Mikrobiol Hyg [B].* 1985 Dec;181(6):496-512.
34. Bottone EJ, Cheng M, Hymes S. "Ineffectiveness of handwashing with lotion soap to remove nosocomial bacterial pathogens persisting on fingertips: a major link in their intrahospital spread." *Infect Control Hosp Epidemiol.* 2004 Mar;25(3):262-4.
35. Bowen JM, Tobin N, Simpson RB, Ley WB, Ansari MM. "Effects of washing on the bacterial flora of the stallion's penis." *J Reprod Fertil Suppl.* 1982;32:41-5.
36. Boyce JM. "New insights for improving hand hygiene practices." *Infect Control Hosp Epidemiol.* 2004 Mar;25(3):187-8.
37. Boyce JM, Pearson ML. "Low frequency of fires from alcohol-based hand rub dispensers in healthcare facilities." *Infect Control Hosp Epidemiol.* 2003 Aug;24(8):618-9.
38. Boyce JM, Pittet D; Healthcare Infection Control Practices Advisory Committee. Society for Healthcare Epidemiology of America. Association for Professionals in Infection Control. Infectious Diseases Society of America. Hand Hygiene Task Force. "Guideline for Hand Hygiene in Health-Care Settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/ APIC/IDSA Hand Hygiene Task Force." *Infect Control Hosp Epidemiol.* 2002 Dec;23(12 Suppl):S3-40.

39. Boyce JM, Pittet D; Healthcare Infection Control Practices Advisory Committee; HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. "Guideline for Hand Hygiene in Health-Care Settings. Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HIPAC/SHEA/APIC/IDSA Hand Hygiene Task Force." *Am J Infect Control*. 2002 Dec;30(8):S1-46.
40. Boyce JM. "MRSA patients: proven methods to treat colonization and infection." *J Hosp Infect*. 2001 Aug;48 Suppl A:S9-14.
41. Boyce JM. "Antiseptic technology: access, affordability, and acceptance." *Emerg Infect Dis*. 2001 Mar-Apr;7(2):231-3.
42. Boyce JM, Kelliher S, Vallande N. "Skin irritation and dryness associated with two hand-hygiene regimens: soap-and-water hand washing versus hand antisepsis with an alcoholic hand gel." *Infect Control Hosp Epidemiol*. 2000 Jul;21(7):442-8.
43. Boyce JM. "Using alcohol for hand antisepsis: dispelling old myths." *Infect Control Hosp Epidemiol*. 2000 Jul;21(7):438-41.
44. Breeze W. "It is time to standardize surgical hand scrubs." *AORN J*. 1994 Aug;60(2):294-6.
45. Brown SM, Lubimova AV, Khrustalyeva NM, Shulaeva SV, Tekhova I, Zueva LP, Goldmann D, O'Rourke EJ. "Use of an alcohol-based hand rub and quality improvement interventions to improve hand hygiene in a Russian neonatal intensive care unit." *Infect Control Hosp Epidemiol*. 2003 Mar;24(3):172-9.
46. Brown TR, Ehrlich CE, Stehman FB, Golichowski AM, Madura JA, Eitzen HE. "A clinical evaluation of chlorhexidine gluconate spray as compared with iodophor scrub for preoperative skin preparation." *Surg Gynecol Obstet*. 1984 Apr;158(4):363-6.
47. Bryant KA, Pearce J, Stover B. "Flash fire associated with the use of alcohol-based antiseptic agent." *Am J Infect Control*. 2002 Jun;30(4):256-7.
48. Burks RI. "Povidone-iodine solution in wound treatment." *Phys Ther*. 1998 Feb;78(2):212-8.
49. Burnie JP, Odds FC, Lee W, Webster C, Williams JD. "Outbreak of systemic *Candida albicans* in intensive care unit caused by cross infection." *Br Med J (Clin Res Ed)*. 1985 Mar 9;290(6470):746-8.
50. Bush LW, Benson LM, White JH. "Pig skin as test substrate for evaluating topical antimicrobial activity." *J Clin Microbiol*. 1986 Sep;24(3):343-8.
51. Butz AM, Laughon BE, Gullette DL, Larson EL. "Alcohol-impregnated wipes as an alternative in hand hygiene." *Am J Infect Control*. 1990 Apr;18(2):70-6.

52. Bydzovska O. "Screening the viricidal efficiency of antiseptics, disinfection and chemical sterilization--a draft methodology for practice." *J Hyg Epidemiol Microbiol Immunol*. 1987;31(4):375-80.
53. Cardoso CL, Pereira HH, Zequim JC, Guilhermetti M. Effectiveness of hand-cleansing agents for removing *Acinetobacter baumannii* strain from contaminated hands." *Am J Infect Control*. 1999 Aug;27(4):327-31.
54. Carr MP, Sullivan S, Gilmore J, Rashid RG. "Preference and compliance of waterless hand-hygiene products versus soap and water." *Am J Dent*. 2003 Sep;16 Spec No:17A-19A.
55. Casewell MW, Law MM, Desai N. "A laboratory model for testing agents for hygienic hand disinfection: handwashing and chlorhexidine for the removal of *klebsiella*." *J Hosp Infect*. 1988 Oct;12(3):163-75.
56. Chamberlain AN, Halablab MA, Gould DJ, Miles RJ. "Distribution of bacteria on hands and the effectiveness of brief and thorough decontamination procedures using non-medicated soap." *Zentralbl Bakteri*. 1997 Apr;285(4):565-75.
57. Charbonneau DL, Ponte JM, Kochanowski BA. "A method of assessing the efficacy of hand sanitizers: use of real soil encountered in the food service industry." *J Food Prot*. 2000 Apr;63(4):495-501.
58. Cheng SM, Garcia M, Espin S, Conly J. "Literature review and survey comparing surgical scrub techniques." *AORN J*. 2001 Aug;74(2):218, 221-4.
59. Cimiotti JP, Stone PW, Larson EL. "A cost comparison of hand hygiene regimens." *Nurs Econ*. 2004 Jul-Aug;22(4):196-9, 204, 175.
60. Cimiotti JP, Marmur ES, Nesin M, Hamlin-Cook P, Larson EL. "Adverse reactions associated with an alcohol-based hand antiseptic among nurses in a neonatal intensive care unit." *Am J Infect Control*. 2003 Feb;31(1):43-8.
61. Conrad C. "Increase in hand-alcohol consumption among medical staff in a general hospital as a result of introducing a training program and a visualization test." *Infect Control Hosp Epidemiol*. 2001 Jan;22(1):41-2.
62. Cooper JA. "The cost of keeping one's hands clean." *Br Dent J*. 1992 Aug 8-22;173(3):86.
63. Craig CP. "Preparation of the skin for surgery." *Infect Control*. 1986 May;7(5):257-8.
64. Cremieux A, Guiraud-Dauriac H, Duval J, Otterbein G, Guilbaud J, Epardeau B, Guillemart A. "Multicenter study in actual situations of the activity of an antiseptic in the surgical washing of hands." *Pathol Biol*. 1984 Jun;32(5 Pt 2):599-603.

65. Crompton DO, Thompson MJ. "Betadine surgical scrub: a warning." *Med J Aust.* 1980 Nov 29;2(11):632.
66. Cronin WA, Groschel DH. "A no-rinse alcohol antiseptic and a no-touch dispenser for hand decontamination." *Infect Control Hosp Epidemiol.* 1989 Feb;10(2):80-3.
67. Crow S. "Handwashing agents." *Infect Control.* 1983 Sep-Oct;4(5):404.
68. Crowder VH Jr, Welsh JS, Bornside GH, Cohn I Jr. "Bacteriological comparison of hexachlorophene and polyvinylpyrrolidone-iodine surgical scrub soaps." *Am Surg.* 1967 Nov;33(11):906-11.
69. Cruse P. "Wound infection surveillance." *Rev Infect Dis.* 1981 Jul-Aug;3(4):734-7.
70. Custer J, Edlich RF, Prusak M, Madden J, Panek P, Wangenstein OH. "Studies in the management of the contaminated wound. V. An assessment of the effectiveness of pHisoHex and Betadine surgical scrub solutions." *Am J Surg.* 1971 May;121(5):572-5.
71. D'Errico MM, Savini S, Prospero E, Annino I. "Report on a packaged handwashing antiseptic contaminated with *Pseudomonas aeruginosa*." *Infect Control Hosp Epidemiol.* 2000 May;21(5):302.
72. Dahl J, Wheeler B, Mukherjee D. "Effect of chlorhexidine scrub on postoperative bacterial counts." *Am J Surg.* 1990 May;159(5):486-8.
73. Daschner FD. "How cost-effective is the present use of antiseptics?" *J Hosp Infect.* 1988 Feb;11 Suppl A:227-35.
74. Davies JG, Babb JR, Bradley CR, Ayliffe GA. "Preliminary study of test methods to assess the virucidal activity of skin disinfectants using poliovirus and bacteriophages." *J Hosp Infect.* 1993 Oct;25(2):125-31.
75. Davies PA. "Please wash your hands." *Arch Dis Child.* 1982 Sep;57(9):647-8.
76. De Gaudio AR, Di Filippo A. "Device-related infections in critically ill patients. Part I: Prevention of catheter-related bloodstream infections." *J Chemother.* 2003 Oct;15(5):419-27.
77. Deshmukh N, Kramer JW, Kjellberg SI. "A comparison of 5-minute povidone-iodine scrub and 1-minute povidone-iodine scrub followed by alcohol foam." *Mil Med.* 1998 Mar;163(3):145-7.
78. Desrochers A, St-Jean G, Anderson DE, Rogers DP, Chengappa MM. "Comparative evaluation of two surgical scrub preparations in cattle." *Vet Surg.* 1996 Jul-Aug;25(4):336-41.
79. Dewar NE, Gravens DL. "Effectiveness of septrisol antiseptic foam as a surgical scrub agent." *Appl Microbiol.* 1973 Oct;26(4):544-9.

80. Dharan S, Hugonnet S, Sax H, Pittet D. "Comparison of waterless hand antisepsis agents at short application times: raising the flag of concern." *Infect Control Hosp Epidemiol*. 2003 Mar;24(3):160-4.
81. Diekema DJ. "Alcohol-based hand gels and hand hygiene in hospitals." *Lancet*. 2002 Nov 9;360(9344):1510; author reply 1511.
82. Dineen P. "Hand-washing degerming: a comparison of povidone-iodine and chlorhexidine." *Clin Pharmacol Ther*. 1978 Jan;23(1):63-7.
83. Doebbeling BN, Stanley GL, Sheetz CT, Pfaller MA, Houston AK, Annis L, LiN, Wenzel RP. "Comparative efficacy of alternative hand-washing agents in reducing nosocomial infections in intensive care units." *N Engl J Med*. 1992 Jul 9;327(2):88-93.
84. Doebbeling BN, Pfaller MA, Houston AK, Wenzel RP. "Removal of nosocomial pathogens from the contaminated glove. Implications for glove reuse and handwashing." *Ann Intern Med*. 1988 Sep 1;109(5):394-8.
85. Dorner I. "Handwashing with chlorhexidine gluconate products." *J Hosp Infect*. 1990 Aug;16(2):182.
86. Douglas CW, Millward TA, Clark A. "The use of various handwashing agents to decontaminate gloved hands." *Br Dent J*. 1989 Jul 22;167(2):62-5.
87. Dyer DL, Gerenraich KB, Wadhams PS. "Testing a new alcohol-free hand sanitizer to combat infection." *AORN J*. 1998 Aug;68(2):239-41, 243-4, 247-51.
88. Eggers HJ. "Experiments on antiviral activity of hand disinfectants. Some theoretical and practical considerations." *Zentralbl Bakteriol*. 1990 May;273(1):36-51.
89. Eitez HE, Ritter MA, French MLV, Gioe TJ. "A microbiological in-use comparison of surgical hand-washing agents." *J Bone Joint Surg*. 1979 (61):403-6.
90. Ekizoglu MT, Ozalp M, Sultan N, Gur D. "An investigation of the bactericidal effect of certain antiseptics and disinfectants on some hospital isolates of gram-negative bacteria." *Infect Control Hosp Epidemiol*. 2003 Mar;24(3):225-7.
91. Faix RG. "Comparative efficacy of handwashing agents against cytomegalovirus." *Infect Control*. 1987 Apr;8(4):158-62.
92. Faoagali J, Fong J, George N, Mahoney P, O'Rourke V. "Comparison of the immediate, residual, and cumulative antibacterial effects of Novaderm R,\* Novascrub R,\* Betadine Surgical Scrub, Hibiclens, and liquid soap." *Am J Infect Control*. 1995 Dec;23(6):337-43.
93. Faoagali JL, George N, Fong J, Davy J, Dowser M. "Comparison of the antibacterial efficacy of 4% chlorhexidine gluconate and 1% triclosan handwash products in an acute clinical ward." *Am J Infect Control*. 1999 Aug;27(4):320-6.

94. Fendler E, Groziak P. "Efficacy of alcohol-based hand sanitizers against fungi and viruses." *Infect Control Hosp Epidemiol*. 2002 Feb;23(2):61-2.
95. Fendler EJ, Ali Y, Hammond BS, Lyons MK, Kelley MB, Vowell NA. "The impact of alcohol hand sanitizer use on infection rates in an extended care facility." *Am J Infect Control*. 2002 Jun;30(4):226-33.
96. Field EA, Martin MV. "Handwashing: soap or disinfectant?" *Br Dent J*. 1986 Apr 19;160(8):278-80.
97. Field EA, Martin MV. "Disinfection of dental surgeons' hands with detergent preparations of triclosan and chlorhexidine." *J Dent*. 1986 Feb;14(1):7-10.
98. Findley WR, Spainhour SE. "Is triclosan susceptible to contamination?" *Infect Control*. 1985 Aug;6(8):298-9.
99. Galle PC, Homesley HD, Rhyne AL. "Reassessment of the surgical scrub." *Surg Gynecol Obstet*. 1978 Aug;147(2):215-8.
100. Galuppo LD, Pascoe JR, Jang SS, Willits NH, Greenman SL. "Evaluation of iodophor skin preparation techniques and factors influencing drainage from ventral midline incisions in horses." *J Am Vet Med Assoc*. 1999 Oct 1;215(7):963-9.
101. Garibaldi RA. "Prevention of intraoperative wound contamination with chlorhexidine shower and scrub." *J Hosp Infect*. 1988 Apr;11 Suppl B:5-9.
102. Gavlick WK, Davis PK. "Gas chromatographic determination of p-chloroaniline in a chlorhexidine digluconate-containing alcohol foam surgical scrub product." *J AOAC Int*. 1994 May-Jun;77(3):583-6.
103. Geelhoed GW, Sharpe K, Simon GL. "A comparative study of surgical skin preparation methods." *Surg Gynecol Obstet*. 1983 Sep;157(3):265-8.
104. Gehrke C, Steinmann J, Goroncy-Bernes P. "Inactivation of feline calicivirus, a surrogate of norovirus (formerly Norwalk-like viruses), by different types of alcohol in vitro and in vivo." *J Hosp Infect*. 2004 Jan;56(1):49-55.
105. Geiss HK, Heeg P. "Hand-washing agents and nosocomial infections." *N Engl J Med*. 1992 Nov 5;327(19):1390.
106. Georgiade GS, Georgiade NG, Grandy RP, Goldenheim PD. "The effect of povidone-iodine solutions used as surgical preparations on the bacterial flora of the skin." *Adv Ther*. 1990 Jan-Feb;7(1):1-8.
107. Gibson LL, Rose JB, Haas CN, Gerba CP, Rusin PA. "Quantitative assessment of risk reduction from hand washing with antibacterial soaps." *J Appl Microbiol*. 2002;92 Suppl:136S-43S.

108. Gidley C. "Now, wash your hands!" *Nurs Times*. 1987 Jul 22-28;83(29):40-2.
109. Girard R, Aho LS, Goetz ML, Labadie JC, Lejeune B; Members of the working group on hand disinfection of the French Society for Hospital Hygiene. "Alcohol-based hand gels and hand hygiene in hospitals." *Lancet*. 2002 Nov 9;360(9344):1510-1.
110. Girou E, Chai SH, Oppein F, Legrand P, Ducellier D, Cizeau F, Brun-Buisson C. "Misuse of gloves: the foundation for poor compliance with hand hygiene and potential for microbial transmission?" *J Hosp Infect*. 2004 Jun;57(2):162-9.
111. Girou E, Loyeau S, Legrand P, Oppein F, Brun-Buisson C. "Efficacy of handrubbing with alcohol based solution versus standard handwashing with antiseptic soap: randomised clinical trial." *BMJ*. 2002 Aug 17;325(7360):362.
112. Girou E, Oppein F. "Handwashing compliance in a French university hospital: new perspective with the introduction of hand-rubbing with a waterless alcohol-based solution." *J Hosp Infect*. 2001 Aug;48 Suppl A:S55-7.
113. Goldenheim PD. "An appraisal of povidone-iodine and wound healing." *Postgrad Med J*. 1993;69 Suppl 3:S97-105.
114. Goldmann D, Larson E. "Hand-washing and nosocomial infections." *N Engl J Med*. 1992 Jul 9;327(2):120-2.
115. Goroncy-Bermes P. "Hand disinfection according to the European Standard EN 1500 (hygienic handrub): a study with gram-negative and gram-positive test organisms." *Int J Hyg Environ Health*. 2001 Nov;204(2-3):123-6.
116. Goroncy-Bermes P, Schouten MA, Voss A. "In vitro activity of a nonmedicated handwash product, chlorhexidine, and an alcohol-based hand disinfectant against multiply resistant gram-positive microorganisms." *Infect Control Hosp Epidemiol*. 2001 Apr;22(4):194-6.
117. Gould D. "Hand decontamination." *Nurs Times*. 2002 Nov 12-18;98(46):48-9.
118. Gould D, Gammon J, Donnelly M, Batiste L, Ball E, De Melo AM, Alidad V, Miles R, Halablab M. "Improving hand hygiene in community healthcare settings: the impact of research and clinical collaboration." *J Clin Nurs*. 2000 Jan;9(1):95-102.
119. Gower WE. "Evaluation of several methods of surgical scrub." *J Indiana State Med Assoc*. 1973 Jul;66(7):645-7.
120. Graham M. "Frequency and duration of handwashing in an intensive care unit." *Am J Infect Control*. 1990 Apr;18(2):77-81.
121. Greene J. "Igniting interest. Hand-rub dispenser locations undergo scrutiny." *Mater Manag Health Care*. 2003 Mar;12(3):32-4.

122. Greig JE, Thoo SL, Carson CF, Riley TV. "Allergic contact dermatitis following use of a tea tree oil hand-wash not due to tea tree oil." *Contact Dermatitis*. 1999 Dec;41(6):354-5.
123. Gross A, Cutright DE, D'Alessandro SM. "Effect of surgical scrub on microbial population under the fingernails." *Am J Surg*. 1979 Sep;138(3):463-7.
124. Gross A, Cofone L, Huff MB. "Iodine inactivating agent in surgical scrub testing." *Arch Surg*. 1973 Feb;106(2):175-8.
125. Grove GL, Zerweck CR, Heilman JM, Pyrek JD. "Methods for evaluating changes in skin condition due to the effects of antimicrobial hand cleansers: two studies comparing a new waterless chlorhexidine gluconate/ethanol-emollient antiseptic preparation with a conventional water-applied product." *Am J Infect Control*. 2001 Dec;29(6):361-9.
126. Gruendemann BJ, Bjerke NB. "Is it time for brushless scrubbing with an alcohol-based agent?" *AORN J*. 2001 Dec;74(6):859-73.
127. Guilhermetti M, Hernandez SE, Fukushigue Y, Garcia LB, Cardoso CL. "Effectiveness of hand-cleansing agents for removing methicillin-resistant *Staphylococcus aureus* from contaminated hands." *Infect Control Hosp Epidemiol*. 2001 Feb;22(2):105-8.
128. Gundermann KO, Christiansen B, Holler C. "New methods for determining pre-operative and postoperative skin disinfection." *J Hosp Infect*. 1985 Mar;6 Suppl A:51-7.
129. Haley RW, Bregman DA. "The role of understaffing and overcrowding in recurrent outbreaks of staphylococcal infection in a neonatal special-care unit." *J Infect Dis*. 1982 Jun;145(6):875-85.
130. Hall R. "Povidone-iodine and chlorhexidine gluconate containing detergents for disinfection of hands." *J Hosp Infect*. 1980 Dec;1(4):367-8.
131. Harbarth S. "Handwashing-the Semmelweis lesson misunderstood?" *Clin Infect Dis*. 2000 Jun;30(6):990-1.
132. Harris C. "MIC tests are not suitable for assessing antiseptic handwashes." *J Hosp Infect*. 1989 Jan;13(1):95.
133. Hayek LJ, Emerson JM. "Preoperative whole body disinfection--a controlled clinical study." *J Hosp Infect*. 1988 Apr;11 Suppl B:15-9.
134. Healthcare Infection Control Practices Advisory Committee and Hand-Hygiene Task Force; Society for Healthcare Epidemiology of America; Association for Professionals in Infection Control and Epidemiology; Infection Diseases Society of America. "Guideline for hand hygiene in healthcare settings." *J Am Coll Surg*. 2004 Jan;198(1):121-7.



135. Heczko PB, Kleszcz P. "Handwashing practices in Polish hospitals: results of a survey conducted by Polish Society of Hospital Infection." *J Hosp Infect.* 2001 Aug;48 Suppl A:S47-9.
136. Hedin G, Hambræus A. "Daily scrub with chlorhexidine reduces skin colonization by antibiotic-resistant *Staphylococcus epidermidis*." *J Hosp Infect.* 1993 May;24(1):47-61.
137. Heeg P. "Does hand care ruin hand disinfection?" *J Hosp Infect.* 2001 Aug;48 Suppl A:S37-9.
138. Hilburn J, Hammond BS, Fendler EJ, Groziak PA. "Use of alcohol hand sanitizer as an infection control strategy in an acute care facility." *Am J Infect Control.* 2003 Apr;31(2):109-16.
139. Hingst V, Juditzki I, Heeg P, Sonntag HG. "Evaluation of the efficacy of surgical hand disinfection following a reduced application time of 3 instead of 5 min." *J Hosp Infect.* 1992 Feb;20(2):79-86.
140. Hobson DW, Woller W, Anderson L, Guthery E. "Development and evaluation of a new alcohol-based surgical hand scrub formulation with persistent antimicrobial characteristics and brushless application." *Am J Infect Control.* 1998 Oct;26(5):507-12.
141. Hoffman P, Cookson B, Teare L. "Alcohol-based hand gels and hand hygiene in hospitals." *Lancet.* 2002 Nov 9;360(9344):1510; author reply 1511.
142. Holloway PM, Platt JH, Reybrouck G, Lilly HA, Mehtar S, Drabu Y. "A multi-centre evaluation of two chlorhexidine-containing formulations for surgical hand disinfection." *J Hosp Infect.* 1990 Aug;16(2):151-9.
143. Holloway PM. "Effect of chlorhexidine on bacterial pathogenicity." *J Hosp Infect.* 1989 Jan;13(1):96.
144. Houston S, Gentry LO, Pruitt V, Dao T, Zabaneh F, Sabo J. "Reducing the incidence of nosocomial pneumonia in cardiovascular surgery patients." *Qual Manag Health Care.* 2003 Jan-Mar;12(1):28-41.
145. Hravnak M, George E, Kormos RL. "Management of chronic left ventricular assist device percutaneous lead insertion sites." *J Heart Lung Transplant.* 1993 Sep-Oct;12(5):856-63.
146. Huang Y, Oie S, Kamiya A. "Comparative effectiveness of hand-cleansing agents for removing methicillin-resistant *Staphylococcus aureus* from experimentally contaminated fingertips." *Am J Infect Control.* 1994 Aug;22(4):224-7.

147. Jackson FE. Therapeutic Advances & New Clinical Implications, Medical and Surgical Antisepsis with Betadine Microbicides. "The utilization of povidone-iodine in the prevention of neurosurgical infections." Proceedings of the Symposium: Departments of Surgery, Epidemiology and Public Health, University of Miami School of Medicine, Florida. 1972:79-86.
148. Jarvis JD, Wynne CD, Enwright L, Williams JD. "Handwashing and antiseptic containing soaps in hospital." *J Clin Path.* 1979 (32):732-37.
149. Jeanes A. "Handwashing: what is the best solution?" *Prof Nurse.* 2004 Oct;20(2):41-4.
150. Jeanes A. "Improving hand hygiene compliance." *Nurs Times.* 2003 Feb 18-24;99(7):47-9.
151. John M. "Hand hygiene: washing and disinfection." *J Can Dent Assoc.* 2000 Nov;66(10): 546-7.
152. Jonczy EA, Daly J, Kotwal GJ. "A novel approach using an attenuated recombinant vaccinia virus to test the antipoxviral effects of handsoaps." *Antiviral Res.* 2000 Feb;45(2):149-53.
153. Jones MV, Rowe GB, Jackson B, Pritchard NJ. "The use of alcoholic paper wipes for routine hand cleansing: results of trials in two hospitals." *J Hosp Infect.* 1986 Nov;8(3):268-74.
154. Jones RD, Jampani HB, Newman JL, Lee AS. "Triclosan: a review of effectiveness and safety in health care settings." *Am J Infect Control.* 2000 Apr;28(2):184-96.
155. Jones RD, Jampani H, Mulberry G, Rizer RL. "Moisturizing alcohol hand gels for surgical hand preparation." *AORN J.* 2000 Mar;71(3):584-7, 589-90, 592.
156. Kampf G, Kramer A. "Epidemiologic background of hand hygiene and evaluation of the most important agents for scrubs and rubs." *Clin Microbiol Rev.* 2004 Oct;17(4):863-93, table of contents.
157. Kampf G. "State-of-the-art hand hygiene in community medicine." *Int J Hyg Environ Health.* 2003 Oct;206(6):465-72.
158. Kampf G, Kapella M. "Suitability of Sterillium Gel for surgical hand disinfection." *J Hosp Infect.* 2003 Jul;54(3):222-5.
159. Kampf G, Muscatiello M, Hantschel D, Rudolf M. "Dermal tolerance and effect on skin hydration of a new ethanol-based hand gel." *J Hosp Infect.* 2002 Dec;52(4):297-301.
160. Kampf G, Ostermeyer C. "Intra-laboratory reproducibility of the hand hygiene reference procedures of EN 1499 (hygienic handwash) and EN 1500 (hygienic hand disinfection)." *J Hosp Infect.* 2002 Nov;52(3):219-24.

161. Kampf G, Hofer M, Wendt C. "Efficacy of hand disinfectants against vancomycin-resistant enterococci in vitro." *J Hosp Infect.* 1999 Jun;42(2):143-50.
162. Kampf G, Jarosch R, Ruden H. "Limited effectiveness of chlorhexidine based hand disinfectants against methicillin-resistant *Staphylococcus aureus* (MRSA)." *J Hosp Infect.* 1998 Apr;38(4):297-303.
163. Kanerva L, Estlander T, Jolanki R. "Occupational allergic contact dermatitis from alkylammonium amidobenzoate." *Eur J Dermatol.* 2001 May-Jun;11(3):240-3.
164. Kaplan JC, Crawford DC, Durno AG, Schooley RT. "Inactivation of human immunodeficiency virus by Betadine." *Infect Control.* 1987 Oct;8(10):412-4.
165. Katz JD. "Hand washing and hand disinfection: more than your mother taught you." *Anesthesiol Clin North America.* 2004 Sep;22(3):457-71.
166. Kawana R, Matsumoto I, Saito J, Higuchi T, Fujiwara M, Takahashi K, Yanagihara T, Takahashi K. "Study of the antiseptic efficacy of a quick drying rubbing type povidone-iodine alcoholic disinfectant solution by the glove juice method." *Postgrad Med J.* 1993;69 Suppl 3:S18-22.
167. Kesavan S, Barodawala S, Mulley GP. "Now wash your hands? A survey of hospital handwashing facilities." *J Hosp Infect.* 1998 Dec;40(4):291-3.
168. Kilpatrick L, Knight RA. "Comparison of the germicidal activity of prepodyne and betadine surgical scrub solutions." *Am J Med Technol.* 1975 May;41(5):180-4.
169. Kirita T, Hamano K, Ochi T, Ihara H, Nishiyama T, Seshimo A, Yagi Y, Sakakida K. "Efficacy and safety of a quick drying rubbing type povidone-iodine alcoholic disinfectant solution." *Postgrad Med J.* 1993;69 Suppl 3:S27-32.
170. Kjolen H, Andersen BM. "Handwashing and disinfection of heavily contaminated hands--effective or ineffective?" *J Hosp Infect.* 1992 May;21(1):61-71.
171. Kobayashi H. "Evaluation of surgical scrubbing." *J Hosp Infect.* 1991 Jun;18 Suppl B:29-34.
172. Kocent H, Corke C, Alajeel A, Graves S. "Washing of gloved hands in antiseptic solution prior to central venous line insertion reduces contamination." *Anaesth Intensive Care.* 2002 Jun;30(3):338-40.
173. Kohan C, Ligi C, Dumigan DG, Boyce JM. "The importance of evaluating product dispensers when selecting alcohol-based handrubs." *Am J Infect Control.* 2002 Oct;30(6):373-5.
174. Koller W, Rotter ML, Gottardi W. "Do chlorine covers exert a sustained bactericidal effect on the bacterial hand flora?" *J Hosp Infect.* 1995 Nov;31(3):169-76.

175. Kovach TL. "Maintaining intact skin during handwashing: the first line of defense against the chain of septic flow." *J Pract Nurs*. 2001 Summer;51(2):21-5.
176. Kramer A, Rudolph P, Kampf G, Pittet D. "Limited efficacy of alcohol-based hand gels." *Lancet*. 2002 Apr 27;359(9316):1489-90.
177. Kundsinn RB, Walter CW. "The surgical scrub--practical consideration." *Arch Surg*. 1973 Jul;107(1):75-7.
178. Lam BC, Tam J, Ng MH, Yeung CY. "Nosocomial gastroenteritis in paediatric patients." *J Hosp Infect*. 1989 Nov;14(4):351-5.
179. Lankford MG, Zembower TR, Trick WE, Hacek DM, Noskin GA, Peterson LR. "Influence of role models and hospital design on hand hygiene of healthcare workers." *Emerg Infect Dis*. 2003 Feb;9(2):217-23.
180. LaRocca PT, LaRocca MA. "Surgical scrubs." *Infect Control*. 1987 Jun;8(6):230-1.
181. Larson E, Aiello A, Lee LV, Della-Latta P, Gomez-Duarte C, Lin S. "Short- and long-term effects of handwashing with antimicrobial or plain soap in the community." *J Community Health*. 2003 Apr;28(2):139-50.
182. Larson E, Silberger M, Jakob K, Whittier S, Lai L, Della Latta P, Saiman L. "Assessment of alternative hand hygiene regimens to improve skin health among neonatal intensive care unit nurses." *Heart Lung*. 2000 Mar-Apr;29(2):136-42.
183. Larson E, Anderson JK, Baxendale L, Bobo L. "Effects of a protective foam on scrubbing and gloving." *Am J Infect Control*. 1993 Dec;21(6):297-301.
184. Larson E, Bobo L. "Effective hand degerming in the presence of blood." *J Emerg Med*. 1992 Jan-Feb;10(1):7-11.
185. Larson E, Rotter ML. "Handwashing: are experimental models a substitute for clinical trials? Two viewpoints." *Infect Control Hosp Epidemiol*. 1990 Feb;11(2):63-6.
186. Larson E. "Handwashing: it's essential--even when you use gloves." *Am J Nurs*. 1989 Jul;89(7):934-9.
187. Larson E, Mayur K, Laughon BA. "Influence of two handwashing frequencies on reduction in colonizing flora with three handwashing products used by health care personnel." *Am J Infect Control*. 1989 Apr;17(2):83-8.
188. Larson E. "Guideline for use of topical antimicrobial agents." *Am J Infect Control*. 1988 Dec;16(6):253-66. Review. Erratum in: *Am J Infect Control* 1991 Feb;19(1):59.
189. Larson E. "Draft guideline for use of topical antimicrobial agents." *Am J Infect Control*. 1987 Dec;15(6):25A-36A.

190. Larson E, Talbot GH. "An approach for selection of health care personnel handwashing agents." *Infect Control*. 1986 Aug;7(8):419-24.
191. Larson E, Leyden JJ, McGinley KJ, Grove GL, Talbot GH. "Physiologic and microbiologic changes in skin related to frequent handwashing." *Infect Control*. 1986 Feb;7(2):59-63.
192. Larson E. "Handwashing and skin. Physiologic and bacteriologic aspects." *Infect Control*. 1985 Jan;6(1):14-23.
193. Larson E. "Effects of handwashing agent, handwashing frequency, and clinical area on hand flora." *Am J Infect Control*. 1984 Apr;12(2):76-82.
194. Larson EL, Aiello AE, Bastyr J, Lyle C, Stahl J, Cronquist A, Lai L, Della-Latta P. "Assessment of two hand hygiene regimens for intensive care unit personnel." *Crit Care Med*. 2001 May;29(5):944-51.
195. Larson EL, Aiello AE, Heilman JM, Lyle CT, Cronquist A, Stahl JB, Della-Latta P. "Comparison of different regimens for surgical hand preparation." *AORN J*. 2001 Feb;73(2):412-4, 417-8, 420.
196. Larson EL. "APIC guideline for handwashing and hand antisepsis in health care settings." *Am J Infect Control*. 1995 Aug;23(4):251-69.
197. Larson EL, Eke PI, Wilder MP, Laughon BE. "Quantity of soap as a variable in handwashing." *Infect Control*. 1987 Sep;8(9):371-5.
198. Larson EL, Eke PI, Laughon BE. "Efficacy of alcohol-based hand rinses under frequent-use conditions." *Antimicrob Agents Chemother*. 1986 Oct;30(4):542-4.
199. Laufman H. "Current use of skin and wound cleansers and antiseptics." *Am J Surg*. 1989 Mar;157(3):359-65.
200. Leaper DJ. "Risk factors for surgical infection." *J Hosp Infect*. 1995 Jun;30 Suppl:127-39.
201. Leclair J. "A review of antiseptics. Cleansing agents." *Today's OR Nurse*. 1990 Oct;12(10):25-8.
202. Lee MG, Hunt P, Felix D. "A comparison of two bactericidal handwashing agents containing chlorhexidine." *J Hosp Infect*. 1988 Jul;12(1):59-63.
203. Leyden JJ, McGinley KJ, Kaminer MS, Bakel J, Nishijima S, Grove MJ, Grove GL. "Computerized image analysis of full-hand touch plates: a method for quantification of surface bacteria on hands and the effect of antimicrobial agents." *J Hosp Infect*. 1991 Jun;18 Suppl B:13-22.

204. Leyden JJ, McGinley KJ, Kates SG, Myung KB. "Subungual bacteria of the hand: contribution to the glove juice test; efficacy of antimicrobial detergents." *Infect Control Hosp Epidemiol*. 1989 Oct;10(10):451-4.
205. Llorens AS. "Reaction to povidone-iodine surgical scrub associated with radical pelvic operations." *Am J Obstet Gynecol*. 1972 Nov 15;114(6):834-5.
206. Loeb MB, Wilcox L, Smaill F, Walter S, Duff Z. "A randomized trial of surgical scrubbing with a brush compared to antiseptic soap alone." *Am J Infect Control*. 1997 Feb;25(1):11-5.
207. Lowbury EJJ, Lilly HA, Ayliffe GAJ. "Preoperative disinfection of surgeons' hands: use of alcoholic solutions and effects of gloves on skin flora." *Brit Med J*. 1974 (16):369-72.
208. Lucet JC, Rigaud MP, Mentre F, Kassis N, Deblangy C, Andremont A, Bouvet E. "Hand contamination before and after different hand hygiene techniques: a randomized clinical trial." *J Hosp Infect*. 2002 Apr;50(4):276-80.
209. Mackintosh CA, Hoffman PN. "An extended model for transfer of micro-organisms via the hands: differences between organisms and the effect of alcohol disinfection." *J Hyg (Lond)*. 1984 Jun;92(3):345-55.
210. Maki DG. "Skin as a source of nosocomial infection: directions for future research." *Infect Control*. 1986 Feb;7(2 Suppl):113-7.
211. Marchetti MG, Kampf G, Finzi G, Salvatorelli G. "Evaluation of the bactericidal effect of five products for surgical hand disinfection according to prEN 12054 and prEN 12791." *J Hosp Infect*. 2003 May;54(1):63-7.
212. Marden W. "A handy sanitizer. CHG becoming primary sterilization agent." *Mater Manag Health Care*. 2002 Oct;11(10):20-3.
213. Marena C, Lodola L, Zecca M, Bulgheroni A, Carretto E, Maserati R, Zambianchi L. "Assessment of handwashing practices with chemical and microbiologic methods: preliminary results from a prospective crossover study." *Am J Infect Control*. 2002 Oct;30(6):334-40.
214. Marino C, Cohen M. "Washington State hospital survey 2000: gloves, handwashing agents, and moisturizers." *Am J Infect Control*. 2001 Dec;29(6):422-4.
215. Martin MA. "Nosocomial infections in intensive care units: an overview of their epidemiology, outcome, and prevention." *New Horiz*. 1993 May;1(2):162-71.
216. Maury E, Alzieu M, Baudel JL, Haram N, Barbut F, Guidet B, Bischoff WE, Reynolds TM, Sessler CN, Edmond MB, Wenzel RP. "Alcohol-based handwashing agent improves hand washing." *Infect Control Hosp Epidemiol*. 2000 Sep;21(9):617-8.

217. Maury E, Alzieu M, Baudel JL, Haram N, Barbut F, Guidet B, Offenstadt G. "Availability of an alcohol solution can improve hand disinfection compliance in an intensive care unit." *Am J Respir Crit Care Med*. 2000 Jul;162(1):324-7.
218. McBride ME, Duncan WC, Knox JM. "An evaluation of surgical scrub brushes." *Surg Gynecol Obstet*. 1973 Dec;137(6):934-6.
219. McDonald LC. "Hand hygiene in the new millennium: drawing the distinction between efficacy and effectiveness." *Infect Control Hosp Epidemiol*. 2003 Mar;24(3):157-9.
220. McDonnell G, Haines K, Klein D, Rippon M, Walmsley R, Pretzer D. "Clinical correlation of a skin antiseptics model." *J Microbiol Methods*. 1999 Feb;35(1):31-5.
221. McLure AR, Gordon J. "In-vitro evaluation of povidone-iodine and chlorhexidine against methicillin-resistant *Staphylococcus aureus*." *J Hosp Infect*. 1992 Aug;21(4):291-9.
222. Meers PD, Yeo GA. "Shedding of bacteria and skin squames after handwashing." *J Hyg (Lond)*. 1978 Aug;81(1):99-105.
223. Meleney FL, Lopez-Mayor JF. "A comparison of the antiseptic value of certain surgical scrub-up preparations." *Am Surg*. 1964 Feb;30:77-82.
224. Mermel LA. "Risk of cutaneous vaccinia from health care workers who receive smallpox vaccine." *JAMA*. 2003 Feb 19;289(7):844-5.
225. Messenger S, Goddard PA, Dettmar PW, Maillard JY. "Comparison of two in vivo and two ex vivo tests to assess the antibacterial activity of several antiseptics." *J Hosp Infect*. 2004 Oct;58(2):115-21.
226. Meurman JH, Pentti P, Suhonen J, Koskela M. "Spray dispensing of antiseptics is effective for hand disinfection." *Scand J Dent Res*. 1989 Dec;97(6):528-32.
227. Michaud RN, McGrath MB, Goss WA. "Application of a gloved-hand model for multi-parameter measurements of skin-degerming activity." *J Clin Microbiol*. 1976 Apr;3(4):406-13.
228. Miller JM, Collier CS. "Clinical use of betadine surgical scrub." *Mil Med*. 1966 Jan;131(1):61-2.
229. Millns B, Martin MV, Field EA. "The sensitivity to chlorhexidine and cetyl pyridinium chloride of staphylococci on the hands of dental students and theatre staff exposed to these disinfectants." *J Hosp Infect*. 1994 Feb;26(2):99-104.
230. Minakuchi K, Yamamoto Y, Matsunaga K, Hayata M, Yasuda T, Katsuno Y, Takada H, Iriyama J, Ishigo S, Asano Y. "The antiseptic effect of a quick drying rubbing type povidone-iodine alcoholic disinfectant solution." *Postgrad Med J*. 1993;69 Suppl 3:S23-6.

231. Mitchell KG, Rawluk DJ. "Skin reactions related to surgical scrub-up: results of a Scottish survey." *Br J Surg*. 1984 Mar;71(3):223-4.
232. Moadab A, Rupley KF, Wadhams P. "Effectiveness of a nonrinse, alcohol-free antiseptic hand wash." *J Am Podiatr Med Assoc*. 2001 Jun;91(6):288-93.
233. Modak S, Sampath L, Miller HS, Millman I. "Rapid inactivation of infectious pathogens by chlorhexidine-coated gloves." *Infect Control Hosp Epidemiol*. 1992 Aug;13(8):463-71.
234. Mody L, McNeil SA, Sun R, Bradley SE, Kauffman CA. "Introduction of a waterless alcohol-based hand rub in a long-term-care facility." *Infect Control Hosp Epidemiol*. 2003 Mar;24(3):165-71.
235. Moralejo D, Jull A. "Handrubbing with an alcohol based solution reduced healthcare workers' hand contamination more than handwashing with antiseptic soap." *Evid Based Nurs*. 2003 Apr;6(2):54-5.
236. Morton JL, Schultz AA. "Healthy Hands: Use of alcohol gel as an adjunct to handwashing in elementary school children." *J Sch Nurs*. 2004 Jun;20(3):161-7.
237. Moureau NL. "Is your skin-prep technique up-to-date?" *Nursing*. 2003 Nov;33(11):17.
238. Mulberry G, Snyder AT, Heilman J, Pyrek J, Stahl J. "Evaluation of a waterless, scrubless chlorhexidine gluconate/ethanol surgical scrub for antimicrobial efficacy." *Am J Infect Control*. 2001 Dec;29(6):377-82.
239. Mullany LC, Darmstadt GL, Tielsch JM. "Role of antimicrobial applications to the umbilical cord in neonates to prevent bacterial colonization and infection: a review of the evidence." *Pediatr Infect Dis J*. 2003 Nov;22(11):996-1002.
240. Murphy LA, White IR. "Contact dermatitis from geraniol in washing-up liquid." *Contact Dermatitis*. 2003 Jul;49(1):52.
241. Muston HL, Boss JM, Summerly R. "Dermatitis from Ammonyx LO, a constituent of a surgical scrub." *Contact Dermatitis*. 1977 Dec;3(6):347-8.
242. Muto CA, Siström MG, Farr BM. "Hand hygiene rates unaffected by installation of dispensers of a rapidly acting hand antiseptic." *Am J Infect Control*. 2000 Jun;28(3):273-6.
243. Myers R. "Hand care and waterlines: update for the dental profession." *Dent Today*. 2004 Oct;23(10):132-6.
244. Myklebust S. "Soap pH and the effectiveness of alcoholic hand antiseptics." *Scand J Dent Res*. 1989 Oct;97(5):451-5.



245. Myklebust S. "Comparative antibacterial effectiveness of seven hand antiseptics." *Scand J Dent Res*. 1985 Dec;93(6):546-54.
246. Nagai I, Ogase H, Takechi M, Kadota M, Kumamoto R. "Evaluation of the disinfectant effect of a quick drying rubbing type povidone-iodine alcoholic solution by the glove juice method." *Postgrad Med J*. 1993;69 Suppl 3:S33-8.
247. Namura S, Nishijima S, Asada Y. "An evaluation of the residual activity of antiseptic handrub lotions: an 'in use' setting study." *J Dermatol*. 1994 Jul;21(7):481-5.
248. Namura S, Nishijima S, Mitsuya K, Asada Y. "Study of the efficacy of antiseptic handrub lotions with hand washing machines." *J Dermatol*. 1994 Jun;21(6):405-10.
249. Namura S, Nishijima S, McGinley KJ, Leyden JJ. "A study of the efficacy of antimicrobial detergents for hand washing: using the full-hand touch plates method." *J Dermatol*. 1993 Feb;20(2):88-93.
250. Newman JL, Seitz JC. "Intermittent use of an antimicrobial hand gel for reducing soap-induced irritation of health care personnel." *Am J Infect Control*. 1990 Jun;18(3):194-200.
251. Newsom SW, Rowland C. "Studies on perioperative skin flora." *J Hosp Infect*. 1988 Apr;11 Suppl B:21-6.
252. Newsom SW, Rowland C, Wells FC. "What is in the surgeon's glove?" *J Hosp Infect*. 1988 Feb;11 Suppl A:244-50.
253. Newsom SW, Matthews J. "Studies on the use of povidone-iodine with the 'hygienic hand disinfection' test." *J Hosp Infect*. 1985 Mar;6 Suppl A:45-50.
254. Ng PC, Wong HL, Lyon DJ, So KW, Liu F, Lam RK, Wong E, Cheng AF, Fok TF. "Combined use of alcohol hand rub and gloves reduces the incidence of late onset infection in very low birthweight infants." *Arch Dis Child Fetal Neonatal Ed*. 2004 Jul;89(4):F336-40.
255. Nicoletti G, Boghossian V, Borland R. "Hygienic hand disinfection: a comparative study with chlorhexidine detergents and soap." *J Hosp Infect*. 1990 May;15(4):323-37.
256. Nishijima S, Namura S, Mitsuya K, Asada Y. "An evaluation, using computerized image analysis, of antimicrobial efficacy of an automatic hand washing machine with ultrasonic wave spraying." *J Dermatol*. 1993 Oct;20(10):654-6.
257. Nobukuni K, Kawahara S. "Thyroid function in nurses: the influence of povidone-iodine hand washing and gargling." *Dermatology*. 2002;204 Suppl 1:99-102.
258. Norman P, Gosden PE, Platt J. "Pseudobacteraemia associated with contaminated skin cleaning agent." *Lancet*. 1986 Jan 25;1(8474):209.

259. Nystrom B. "Impact of handwashing on mortality in intensive care: examination of the evidence." *Infect Control Hosp Epidemiol*. 1994 Jul;15(7):435-6.
260. O'Grady NP, Alexander M, Dellinger EP, Gerberding JL, Heard SO, Maki DG, Masur H, McCormick RD, Mermel LA, Pearson ML, Raad II, Randolph A, Weinstein RA; Healthcare Infection Control Practices Advisory Committee. "Guidelines for the prevention of intravascular catheter-related infections." *Am J Infect Control*. 2002 Dec;30(8):476-89.
261. O'Shaughnessy M, O'Malley VP, Corbett G, Given HF. "Optimum duration of surgical scrub-time." *Br J Surg*. 1991 Jun;78(6):685-6.
262. Ojajarvi J. "Alcohol handrubs v soap. Finnish experience shows that alcohol rubs are good for hands." *BMJ*. 2003 Jan 4;326(7379):50.
263. Ojajarvi J. "Handwashing in Finland." *J Hosp Infect*. 1991 Jun;18 Suppl B:35-40.
264. Olson J. "Splish splash... Adding alcohol-based handrubs to hand hygiene routines contributes to patient safety, saves lives and adds to operational efficiency." *Contemp Longterm Care*. 2004 May-Jun;27(4):34-5.
265. Palenik CJ. "Hand hygiene; bring on the alcohol rubs." *Dent Today*. 2003 Dec;22(12):44-9.
266. Patman RD. "Evaluation of a new antiseptic foam used after the surgical scrub." *Curr Ther Res Clin Exp*. 1966 Jan;8(1):3-6.
267. Paul JW, Gordon MA. "Efficacy of chlorhexidine surgical scrub compared to that of hexachlorophene and povidone-iodine." *Vet Med Small Anim Clin*. 1978 May;73(5):573-6, 579.
268. Paulson DS. "Hand scrub products--performance requirements versus clinical relevance." *AORN J*. 2004 Aug;80(2):225-34.
269. Paulson DS, Fendler EJ, Dolan MJ, Williams RA. "A close look at alcohol gel as an antimicrobial sanitizing agent." *Am J Infect Control*. 1999 Aug;27(4):332-8.
270. Paulson DS. "Comparative evaluation of five surgical hand scrub preparations." *AORN J*. 1994 Aug;60(2):246, 249-56.
271. Pessoa-Silva CL, Dharan S, Hugonnet S, Touveneau S, Posfay-Barbe K, Pfister R, Pittet D. "Dynamics of bacterial hand contamination during routine neonatal care." *Infect Control Hosp Epidemiol*. 2004 Mar;25(3):192-7.
272. Peterson AF, Rosenberg A, Alatary SD. "Comparative evaluation of surgical scrub preparations." *Surg Gynecol Obstet*. 1978 Jan;146(1):63-5.

273. Picheansathian W. "A systematic review on the effectiveness of alcohol-based solutions for hand hygiene." *Int J Nurs Pract*. 2004 Feb;10(1):3-9.
274. Pietsch H. "Hand antiseptics: rubs versus scrubs, alcoholic solutions versus alcoholic gels." *J Hosp Infect*. 2001 Aug;48 Suppl A:S33-6.
275. Pitten FA, Rudolph P, Below H, Kramer A. "Assessment of the activity of antiperspirants added to surgical hand disinfectants: methodological aspects and first observations." *Hosp Infect*. 2001 Aug;48 Suppl A:S29-32.
276. Pittet D, Sax H, Hugonnet S, Harbarth S. "Cost implications of successful hand hygiene promotion." *Infect Control Hosp Epidemiol*. 2004 Mar;25(3):264-6.
277. Pittet D. "Hand hygiene: improved standards and practice for hospital care." *Curr Opin Infect Dis*. 2003 Aug;16(4):327-35.
278. Pittet D, Boyce JM. "Revolutionising hand hygiene in health-care settings: guidelines revisited." *Lancet Infect Dis*. 2003 May;3(5):269-70.
279. Pittet D. "Compliance with hand disinfection and its impact on hospital-acquired infections." *J Hosp Infect*. 2001 Aug;48 Suppl A:S40-6.
280. Pittet D. "Improving adherence to hand hygiene practice: a multidisciplinary approach." *Emerg Infect Dis*. 2001 Mar-Apr;7(2):234-40.
281. Pittet D, Hugonnet S, Harbarth S, Mourouga P, Sauvan V, Touveneau S, Perneger TV. "Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. Infection Control Programme." *Lancet*. 2000 Oct 14;356(9238):1307-12. Erratum in: *Lancet* 2000 Dec 23-30;356(9248):2196.
282. Platt J, Bucknall RA. "The disinfection of respiratory syncytial virus by isopropanol and a chlorhexidine-detergent handwash." *J Hosp Infect*. 1985 Mar;6(1):89-94.
283. Platt JH, Bucknall RA. "MIC tests are not suitable for assessing antiseptic handwashes." *J Hosp Infect*. 1988 May;11(4):396-7.
284. Pressly KB. "Alcohol gel artifact." *Am J Infect Control*. 2000 Aug;28(4):322-3.
285. Pugliese G, Favero MS. "Effect of dispensers and hand antiseptic on hand hygiene." *Infect Control Hosp Epidemiol*. 2000 Aug;21(8):495.
286. Puthuchear SD, Thong ML, Parasakthi N. "Evaluation of some hand washing and disinfection methods in the removal of transient bacterial flora." *Malays J Pathol*. 1981 Aug;4:49-55.
287. Reid AB, Stranc MF. "Healing of infected wounds following iodine scrub or CO2 laser treatment." *Lasers Surg Med*. 1991;11(5):475-80.

288. Reiss-Levy E, McAlister E, Richards M. "Hand-washing and antiseptics." *Med J Aust.* 1984 Feb 18;140(4):245.
289. Reverdy ME, Martra A, Fleurette J. "Effectiveness of 9 soaps and/or antiseptics on hand flora after surgical-type washing." *Pathol Biol (Paris).* 1984 Jun;32(5 Pt 2):591-5.
290. Roberts HS, Self RJ, Coxon M. "An unusual complication of hand hygiene." *Anaesthesia.* 2005 Jan;60(1):100-1.
291. Rochon-Edouard S, Pons JL, Veber B, Larkin M, Vassal S, Lemeland JF. "Comparative in vitro and in vivo study of nine alcohol-based handrubs." *Am J Infect Control.* 2004 Jun;32(4):200-4.
292. Rodeheaver G, Bellamy W, Kody M, Spatafora G, Fitton L, Leyden K, Edlich R. "Bactericidal activity and toxicity of iodine-containing solutions in wounds." *Arch Surg.* 1982 Feb;117(2):181-6.
293. Rose JB, Haas CN. "A risk assessment framework for the evaluation of skin infections and the potential impact of antibacterial soap washing." *Am J Infect Control.* 1999 Dec;27(6): S26-33.
294. Rossoff LJ, Borenstein M, Isenberg HD. "Is hand washing really needed in an intensive care unit?" *Crit Care Med.* 1995 Jul;23(7):1211-6.
295. Rotter M. "Are models useful for testing hand antiseptics?" *J Hosp Infect.* 1988 Feb;11 Suppl A:236-43.
296. Rotter M, Koller W, Wewalka G. "Povidone-iodine and chlorhexidine gluconate-containing detergents for disinfection of hands." *J Hosp Infect.* 1980 Jun;1(2):149-58.
297. Rotter ML. "European norms in hand hygiene." *J Hosp Infect.* 2004 Apr;56 Suppl 2:S6-9.
298. Rotter ML. "Arguments for alcoholic hand disinfection." *J Hosp Infect.* 2001 Aug;48 Suppl A:S4-8.
299. Rotter ML, Simpson RA, Koller W. "Surgical hand disinfection with alcohols at various concentrations: parallel experiments using the new proposed European standards method." *Infect Control Hosp Epidemiol.* 1998 Oct;19(10):778-81.
300. Rotter ML, Koller W, Neumann R. "The influence of cosmetic additives on the acceptability of alcohol-based hand disinfectants." *J Hosp Infect.* 1991 Jun;18 Suppl B:57-63.
301. Rotter ML, Koller W. "Surgical hand disinfection: effect of sequential use of two chlorhexidine preparations." *J Hosp Infect.* 1990 Aug;16(2):161-6.

302. Rotter ML, Hirschl AM, Koller W. "Effect of chlorhexidine-containing detergent, non-medicated soap or isopropanol and the influence of neutralizer on bacterial pathogenicity." *J Hosp Infect.* 1988 Apr;11(3):220-5.
303. Rotter ML. "Povidone-iodine and chlorhexidine gluconate containing detergents for disinfection of hands." *J Hosp Infect.* 1981 Sep;2(3):273-5.
304. Rubin L, Kaplan EG. "Septisol foam antiseptic." *J Foot Surg.* 1979 Summer;18(2):59-60.
305. Rubio PA. "Septisol antiseptic foam: a sensible alternative to the conventional surgical scrub." *Int Surg.* 1987 Oct-Dec;72(4):243-6.
306. Russell AD, Furr JR. "Inactivation of human immunodeficiency virus by chlorhexidine: the possible role of neutralizers." *J Hosp Infect.* 1991 Jul;18(3):249-51.
307. Sattar SA, Springthorpe VS, Tetro J, Vashon R, Keswick B. "Hygienic hand antiseptics: should they not have activity and label claims against viruses?" *Am J Infect Control.* 2002 Oct;30(6):355-72.
308. Sattar SA, Abebe M, Bueti AJ, Jampani H, Newman J, Hua S. "Activity of an alcohol-based hand gel against human adeno-, rhino-, and rotaviruses using the fingerpad method." *Infect Control Hosp Epidemiol.* 2000 Aug;21(8):516-9.
309. Sattar SA, Jacobsen H, Springthorpe VS, Cusack TM, Rubino JR. "Chemical disinfection to interrupt transfer of rhinovirus type 14 from environmental surfaces to hands." *Appl Environ Microbiol.* 1993 May;59(5):1579-85.
310. Scott D, Barnes A, Lister M, Arkell P. "An evaluation of the user acceptability of chlorhexidine handwash formulations." *J Hosp Infect.* 1991 Jun;18 Suppl B:51-5.
311. Sebben JE. "Surgical antiseptics." *J Am Acad Dermatol.* 1983 Nov;9(5):759-65.
312. Serkey JM, Hall GS. "Handwashing compliance: what works?" *Cleve Clin J Med.* 2001 Apr;68(4):325-9, 333-4, 336.
313. Shann FA. "Antiseptic solutions used in Papua New Guinea." *P N G Med J.* 1982 Jun;25(2):79-80.
314. Sickbert-Bennett EE, Weber DJ, Gergen-Teague MF, Rutala WA. "The effects of test variables on the efficacy of hand hygiene agents." *Am J Infect Control.* 2004 Apr;32(2):69-83.
315. Soulsby ME, Barnett JB, Maddox S. "The antiseptic efficacy of chlorxylenol-containing vs. chlorhexidine gluconate-containing surgical scrub preparations." *Infect Control.* 1986 Apr;7(4):223-6.
316. Springer R. "To brush or not to brush...?" *Plast Surg Nurs.* 2002 Winter;22(4):185-7.

317. Stiles ME, Sheena AZ. "Efficacy of low-concentration iodophors for germicidal hand washing." *J Hyg (Lond)*. 1985 Jun;94(3):269-77.
318. Storr J. "A vital campaign." *Health Estate*. 2003 Nov;57(10):48-9.
319. Stratton CW. "Waterless agents for decontaminating the hands." *Infect Control*. 1986 Mar;7(3):186-7.
320. Susman E. "Too clean for comfort." *Environ Health Perspect*. 2001 Jan;109(1):A18.
321. Swaim SF, Riddell KP, Geiger DL, Hathcock TL, McGuire JA. "Evaluation of surgical scrub and antiseptic solutions for surgical preparation of canine paws." *J Am Vet Med Assoc*. 1991 Jun 1;198(11):1941-5.
322. Tammelin A, Klotz F, Hambraeus A, Stahle E, Ransjo U. "Nasal and hand carriage of *Staphylococcus aureus* in staff at a Department for Thoracic and Cardiovascular Surgery: endogenous or exogenous source?" *Infect Control Hosp Epidemiol*. 2003 Sep;24(9):686-9.
323. Tanaka K, Kumon K, Hirata T, Yamamoto F, Fujita T. "Evaluation of rapid drying hand disinfectant preparations in the intensive care unit." *Crit Care Med*. 1988 May;16(5):540-2.
324. Taroni F, Moro ML, Binkin N. "Hand-washing agents and nosocomial infections." *N Engl J Med*. 1992 Nov 5;327(19):1390.
325. Teare L, Cookson B, Stone S. "Hand hygiene." *BMJ*. 2001 Aug 25;323(7310):411-2.
326. Thakerar A, Goodbourn C. "Alcohol handrubs v soap. Alcohol handrub removes methicillin resistant *Staphylococcus aureus*." *BMJ*. 2003 Jan 4;326(7379):50.
327. Toshima Y, Ojima M, Yamada H, Mori H, Tonomura M, Hioki Y, Koya E. "Observation of everyday hand-washing behavior of Japanese, and effects of antibacterial soap." *Int J Food Microbiol*. 2001 Aug 15;68(1-2):83-91.
328. Trampuz A, Widmer AF. "Hand hygiene: a frequently missed lifesaving opportunity during patient care." *Mayo Clin Proc*. 2004 Jan;79(1):109-16.
329. Traore O, Springthorpe VS, Sattar SA. "Testing chemical germicides against *Candida* species using quantitative carrier and fingerpad methods." *J Hosp Infect*. 2002 Jan;50(1):66-75.
330. Tucci VJ, Stone AM, Thompson C, Isenberg HD, Wise L. "Studies of the surgical scrub." *Surg Gynecol Obstet*. 1977 Sep;145(3):415-6.
331. Tunevall TG. "Procedures and experiences with preoperative skin preparation in Sweden." *J Hosp Infect*. 1988 Apr;11 Suppl B:11-4.

332. Tung FF, Estafan D, Scherer W. "The antimicrobial properties of a urea-based handwash lotion with triclosan." *Gen Dent*. 2001 Nov-Dec;49(6):653-6.
333. Tyzack R. "The management of methicillin-resistant *Staphylococcus aureus* in a major hospital." *J Hosp Infect*. 1985 Mar;6 Suppl A:195-9.
334. Voss A, Widmer A, Pittet D. "Hand antisepsis: evaluation of a sprayer system for alcohol distribution." *Infect Control Hosp Epidemiol*. 2003 Sep;24(9):637; author reply 637-8.
335. Voss A, Schulin T, Verweij PE. "Culture and infection control." *Lancet*. 2003 May 10;361(9369):1657.
336. Wade JJ, Desai N, Casewell MW. "Hygienic hand disinfection for the removal of epidemic vancomycin-resistant *Enterococcus faecium* and gentamicin-resistant *Enterobacter cloacae*." *J Hosp Infect*. 1991 Jul;18(3):211-8.
337. Wade JJ, Casewell MW. "The evaluation of residual antimicrobial activity on hands and its clinical relevance." *J Hosp Infect*. 1991 Jun;18 Suppl B:23-8.
338. Walsh B, Blakemore PH, Drabu YJ. "The effect of handcream on the antibacterial activity of chlorhexidine gluconate." *J Hosp Infect*. 1987 Jan;9(1):30-3.
339. Wan PY, Blackford JT, Bemis DA, Rohrbach BW, Knoll DE, Provenza MK. "Evaluation of surgical scrub methods for large animal surgeons." *Vet Surg*. 1997 Sep-Oct;26(5):382-5.
340. Weber DJ, Sickbert-Bennett E, Gergen MF, Rutala WA. "Efficacy of selected hand hygiene agents used to remove *Bacillus atrophaeus* (a surrogate of *Bacillus anthracis*) from contaminated hands." *JAMA*. 2003 Mar 12;289(10):1274-7.
341. Webster J, Faoagali JL, Cartwright D. "Elimination of methicillin-resistant *Staphylococcus aureus* from a neonatal intensive care unit after hand washing with triclosan." *J Paediatr Child Health*. 1994 Feb;30(1):59-64.
342. Webster J. "Handwashing in a neonatal intensive care nursery: product acceptability and effectiveness of chlorhexidine gluconate 4% and triclosan 1%." *J Hosp Infect*. 1992 Jun;21(2):137-41.
343. Webster J. "Hand-washing in a neonatal intensive care unit: comparative effectiveness of chlorhexidine gluconate 4% w/v and triclosan 1% w/v." *Aust Coll Midwives Inc J*. 1991 Sep;4(2):25-7.
344. Webster J, Faoagali JL. "An in-use comparison of chlorhexidine gluconate 4% w/v, glycol-poly-siloxane plus methylcellulose and a liquid soap in a special care baby unit." *J Hosp Infect*. 1989 Aug;14(2):141-51.

345. Welbourn CR, Jones SM. "Hand washing. Alcohol hand rubs are better than soap and water." *BMJ*. 1999 Aug 21;319(7208):519.
346. Wendt C, Knautz D, von Baum H. "Differences in hand hygiene behavior related to the contamination risk of healthcare activities in different groups of healthcare workers." *Infect Control Hosp Epidemiol*. 2004 Mar;25(3):203-6.
347. Wendt C. "Hand hygiene--comparison of international recommendations." *J Hosp Infect*. 2001 Aug;48 Suppl A:S23-8.
348. Wheelock SM, Lookinland S. "Effect of surgical hand scrub time on subsequent bacterial growth." *AORN J*. 1997 (65):1087-98.
349. White C, Kolble R, Carlson R, Lipson N, Dolan M, Ali Y, Cline M. "The effect of hand hygiene on illness rate among students in university residence halls." *Am J Infect Control*. 2003 Oct;31(6):364-70.
350. White JJ, Duncan A. "The comparative effectiveness of iodophor and hexachlorophene surgical scrub solutions." *Surg Gynecol Obstet*. 1972 Dec;135(6):890-2.
351. Widmer AE, Dangel M. "Alcohol-based handrub: evaluation of technique and microbiological efficacy with international infection control professionals." *Infect Control Hosp Epidemiol*. 2004 Mar;25(3):207-9.
352. Wilcox MH, Spencer RC. "Hand-washing agents and nosocomial infections." *N Engl J Med*. 1992 Nov 5;327(19):1390; author reply 1390-1.
353. Winnefeld M, Richard MA, Drancourt M, Grob JJ. "Skin tolerance and effectiveness of two hand decontamination procedures in everyday hospital use." *Br J Dermatol*. 2000 Sep;143(3):546-50.
354. Wolff MH, Schmitt J, Rahaas M, Konig A. "Hepatitis A virus: a test method for virucidal activity." *J Hosp Infect*. 2001 Aug;48 Suppl A:S18-22.
355. Wong CS, Beck MH. "Allergic contact dermatitis from triclosan in antibacterial handwashes." *Contact Dermatitis*. 2001 Nov;45(5):307.
356. Worthington T, Elliott TS. "B4 Hand Hygienic Advanced Skin Protection(TM)-a handy adjunct in the prevention of cross-infection?" *J Hosp Infect*. 2003 Oct;55(2):154-6.
357. Wutzler P, Sauerbrei A. "Virucidal efficacy of a combination of 0.2% peracetic acid and 80% (v/v) ethanol (PAA-ethanol) as a potential hand disinfectant." *J Hosp Infect*. 2000 Dec;46(4):304-8.
358. Zafar AB, Butler RC, Reese DJ, Gaydos LA, Mennonna PA. "Use of 0.3% triclosan (Bacti-Stat) to eradicate an outbreak of methicillin-resistant *Staphylococcus aureus* in a neonatal nursery." *Am J Infect Control*. 1995 Jun;23(3):200-8.



359. Zimmerman FC. "Comparison of three skin preparation techniques in the dog." *Vet Surg.* 1990 Nov-Dec;19(6):405.
360. No authors listed. "Handwashing versus alcohol-based gels--FDA information." *J Environ Health.* 2003 Sep;66(2):40.
361. No authors listed. "Track compliance with hand hygiene guidelines." *Hosp Peer Rev.* 2003 Sep;28(9):120-2.
362. No authors listed. "CDC: alcohol-based handrubs are better than soap & water." *RN.* 2003 Jan;66(1):14.
363. No authors listed. "Waterless washing?" *Health News.* 2000 Oct;6(10):6.
364. No authors listed. "Proposed recommended practices for surgical hand scrubs. Association of Operating Room Nurses." *AORN J.* 1994 Aug;60(2):270, 273-6, 279-80.
365. No authors listed. "CDC guidelines for prevention of surgical wound infections, 1985." *Today's OR Nurse.* 1986 Mar;8(3):33-40.
366. No authors listed. "The appropriate testing methods for OR Scrub?" *Infect Control.* 1984 Dec;5(12):553-5.
367. No authors listed. "The surgical scrub." *Br Med J.* 1970 Aug 22;3(720):418.